THE MODEL ENGINEER

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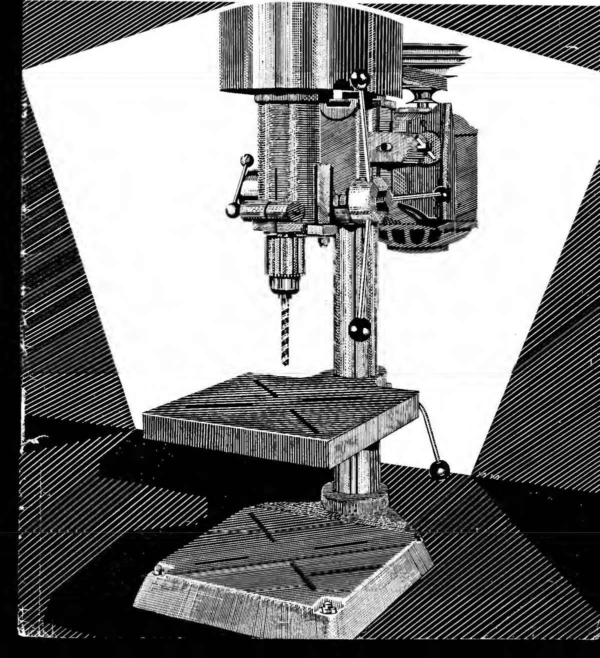

THE

MODEL ENGINEER

Percival Marshall & Co. Ltd., 23, Great Queen Street, London, W.C.2

SMOKE RINGS

Our Cover Picture

THERE is a story behind the cover picture on this issue. In the first place, it marks a change in the style of illustration, which is an appropriate milestone in the development of THE MODEL ENGINEER. We do not say that all our future cover pictures will be in this very modern style, for we shall have photographs which in themselves will be worthy of that post of honour. But as an experiment we asked Mr. Mudge Marriott to transform a photograph into a line drawing, and we hope you will be pleased with the effective treatment he has adopted. It is, we think, unique as a technical journal cover picture, and is well worth careful study as a sample of clever draughtsmanship. For the original photograph we are indebted to Mr. Victor Hart, of Chippenham. It depicts a drilling machine, with a capacity of from 0 in.-½ in., which he has recently completed. He says he made his own patterns and had these cast at a local foundry, where some of the heavier machining was also done for him. Mr. Hart is an invalid who finds model making an agreeable occupation, and a very helpful solace. He also belongs to that distinguished army of mechanics who are left-handed in their work. In submitting his photograph, quite a good one, he modestly suggested that it might be found suitable for the cover. We congratulate him on his excellent piece of machine-tool building, and have marked our appreciation by giving it the place of honour in our new gallery of effective cover pictures.

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Vol. 96 No. 2382
JANUARY 2nd, 1947

A Good New Year to You All

HERE'S wishing you all good health and good fortune in 1947, with a particularly kind thought for my friends over the Border. What the New Year may hold in store for us is beyond my power to prophesy, but I think we may all look forward to much progress and to much enjoyment in our hobby. New records with the speed-boats, racing cars, and power-driven 'planes, will no doubt be reported in our pages and bring laurels to their respective contestants, but in many a home workshop the hours will pass in the quiet completion of a favourite locomotive, or beam or traction engine. Whatever the purpose in view, may the year be a fruitful one for you and bring you much pleasant occupation and successful achievement. The helping hand of THE MODEL ENGINEER and my good wishes will always be with you.

On the Far West Coast

WESTERN Canada is becoming very model conscious again and I am pleased to hear from Mr. W. R. Johnson, of Vancouver, that the British Columbia Society of Model Engineers, founded by him eighteen years ago, is now in full swing once more. He writes :—" In Canada members of the craft are now picking up their tools again. Not without a sad

thought for those whose model-making days are over. The B.C. Society of Model and Experimental Engineers, which was founded by the writer, in this city in 1928, has reorganised, and is increasing its membership. It has a kindly patron in the person of the editor of the *Vancouver Sun* paper. We have been given meeting quarters in the Shelley Building, and are promised a still better meeting place when *The Sun* builds its new auditorium. Meetings are held regularly on the first and third Tuesdays of each month. Mr. H. J. Rees, of the Winnepeg Club, is residing in Vancouver now. This outstanding model locomotive man needs little introduction to you. Our scale locomotive track at Brighouse, on the property of Mr. W. Prescott, which was taken over entirely by the wild blackberries during the war years, is now clear again, and snorts and puffs are heard once more at week-ends. Among the outstanding locomotive builders are Mr. Anthony Twyford, Mr. F. Swinton, Mr. J. E. Wood, and Mr. Fred Pearson."

What is a Professional Model Engineer ?

A CORRESPONDENT raises a point which I think may be of interest to those clubs which organise competitions for prizes, and also the model makers who enter for them. He asks : " If a model is entered in an exhibition for competition and is awarded a money prize, does this put the maker in the professional class ? " In most branches of sport the acceptance of prizes in the form of cash is considered to be a disqualification for amateur recognition. I am aware, of course, that the spirit of this definition is sometimes transgressed by allowances for expenses, by the acceptance of gifts of equipment from trade supply firms, and by the prompt disposal of trophies for cash. Where these practices prevail the dividing line between amateur and professional is a very nebulous affair. In the MODEL ENGINEER Exhibition we have always endeavoured to preserve the hobby aspect of our competition section in two ways. Firstly, we debar entries from people engaged in the model engineering business, either as principals or employees, and secondly, although many of our prizes have a money value, the actual cash is not paid over, but instead thereof an order on a trade firm is given so that the successful competitor may choose a prize to his own liking. We do accept entries from professional engineers or mechanics provided that the work shown has been done in spare time at home entirely as a recreation. In these instances, however, the competitor has to declare his occupation or his technical training, and a higher standard of work is accordingly expected by the judges. This has so far worked extremely well and no complaints about the fairness of its operation have arisen. We have in the past found an occasional instance of a competitor building a model deliberately for sale and hoping that any award he might obtain could be quoted by him to obtain a higher selling price. Such transgressors of the spirit of the competition have found their future entries rejected. I do not think that an isolated instance of the acceptance of a cash prize need give any model engineer qualms about his status as an amateur, but if the conditions of THE MODEL ENGINEER Exhibition were more generally followed it would do much to clarify the position. Where a competitor in open competition is found to be persistently chasing cash prizes, I think the organising committee would be bound to take notice. Local exhibitions and competitions are growing so much in number that the whole question is one calling for a careful examination. I think I might add that the sale of a model for private reasons, as often happens, does not really affect the point at issue.

Television at the Telephone

I RECENTLY mentioned that my old Professor of Engineering, John Perry, had predicted the introduction of an attachment to the ordinary telephone, whereby the person at one end of the line could see an image of the speaker at the other end. Mr. R. Limmer now writes to tell me that such a device was actually in use in Germany, in 1937 or 1938. These instruments were fitted to call-boxes, but not to private subscribers' 'phones. I do not know if this invention will make its way into our country, but I think it very probable that a combination of television and radio will bring receiving sets into being whereby you will see the image of the person who is talking or singing to you. This, of course, is the function of the modern television receiving set, but I am thinking rather of the normal wireless receiver plus a small television attachment, which might be less expensive than a full television receiver. Just an idea !

Electronics for Model Engineers

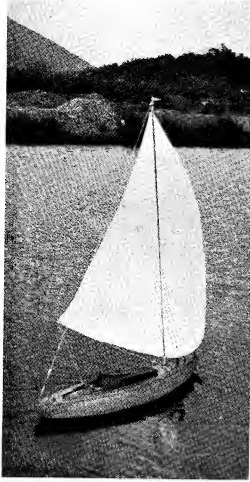
I AM glad to hear that the enthusiastic band of model engineers associated with the Social and Athletic Club of the General Electric Company, is resuming active life again. It has adopted a new title—Model Engineering and Electronics Society—the first of such clubs to declare its interest in the modern developments of electrical science. This obviously broadens the scope of its activities, and will, I imagine, do much to encourage some interesting experimental work by its members. Mr. L. V. Ricards, who did so much for the club in its pre-war days, is again acting as Honorary Secretary, and will be pleased to hear from any of his model engineering friends, at Magnet House, Kingsway, W.C.2.

The "M.E. Index

ANOTHER volume of THE MODEL ENGINEER has now been completed and we repeat our offer to supply subscribers and regular readers with the index for Volume 95, if they will send us a stamped, addressed envelope (1d.) of sufficient size to take a copy of the journal flat. The index will not be printed until we know how many copies are required to fill the demand, but readers are requested to make early application.

Percival Marshall

BEGINNING WITH *Peroma* ★



★ "Peroma" — a radio-controlled auxiliary model yacht with an unusual rig, made as a first effort by an officer stationed in Germany

Col. J. B. ADAMS

I MIGHT have called this article "Something from Nothing," as its main object is to show that enjoyment and results can be obtained from model making, even if one starts with no experience, no workshop, no tools and no material! I must therefore apologise in advance if this aspect is somewhat stressed throughout this description of the making of a radio-controlled auxiliary yacht. I chose the title above as not only was this my first attempt at model making, but also it is literally true, the choice of name being settled long before the boat started to take shape either on paper or in fact—it being made up of the first two letters of the names of my wife and children.

Early History

I have been stationed in Germany for some time and decided towards the end of Summer in 1945 that I must find some hobby to keep me busy during the winter evenings. Having always been inclined towards "gadgets," I decided I must make something and as my line of business in the Army is "Signals," a radio-controlled boat seemed to be indicated. The decision to make it a yacht came when I realised that a model yacht which could be made to tack at will would certainly be entertaining, and if I failed to achieve that, I hoped I would at least have a boat which my children (not to mention Father) could sail. The choice had the following advantages :—

(*a*) I knew nothing about boat construction and had little experience of sailing, and could therefore learn something.

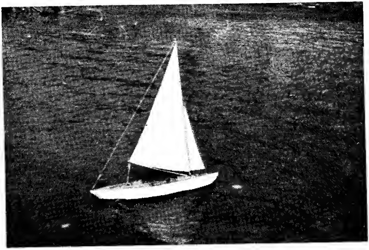
(*b*) It would give me mental exercise in the designing and drawing stages.

(*c*) I should have to learn something about both wood and metal working to complete the job.

(*d*) As far as I knew the idea of a radio-controlled yacht (as opposed to power-boat) was novel. I was probably quite wrong there.

Designing

I was fortunate in being able to borrow copies of four of Uffa Fox's delightful books on yachts and yachting, from which I learnt the mysteries of hull shapes, the meaning of "lines," and the principles of sailing. From another book I learned the meaning of "balance" in a ship and how to calculate displacement, centres of pressure, etc. I soon decided that what I should want to control were :—



A general view of "Peroma" sailing

1. A main sheet to pull in or let out the boom of the mainsail.
2. The rudder.
3. The jib.
4. The change-over from sail to power and *vice versa*.
5. The motor for forward or reverse under power.

The first of the thousand and one snags then appeared, and I would emphasise here something which my readers must have realised long ago, that it is in overcoming the snags that the real enjoyment of experimental work is achieved. This particular horror was that I could not relate the movement of the jib to that of the main boom, since the latter must go in or out on either tack whereas the former must remain held to either side depending on the tack, and I knew I could not afford room for two separate control motors.

The answer was easy—to abolish both jib and mainboom, and to use a modern Scandinavian rig, the Lungström rig, which I found described in one of Uffa Fox's books. For those that are not familiar with it, a brief description will show that it was ideal for my purpose and, in fact, allowed me to introduce another control function —reefing of the mainsail. The rig consists of mainsail only, of Bermudian shape and with no boom, the whole of the luff being fixed to a fairly flexible mast which can swivel in the deck. There are no shrouds, crosstrees or forestays, only a single backstay, and reefing is done to any required degree simply by rotating the mast. There are, in fact, two identical mainsails side by side normally acting as one (with, of course, separate sheets), but when running they are opened out like the pages of a book to give a mainsail either side in lieu of a spinnaker.

Before starting on the hull design I had to know approximately the size and weight of the main components to go inside, the three main ones being the wireless receiver, the batteries and the motor which would drive either the propeller or the winch for the main sheets. In addition there would be various relays, switches, solenoids, etc. I reckoned that by using miniature components I could get the receiver (with its own batteries) down to about 2 lb. weight and small dimensions which would not be a limiting factor. A friend kindly gave me some old nickel-iron 5-ampere-hour cells, each $1\frac{1}{2}$ in. square by about 6 in. high, so with five of these in series to give me 6 volts, I found another 6 lb. of weight taken up; and finally after much searching, I found an abandoned car with a 6-volt windscreen wiper, which yielded up a shunt-wound electric motor weighing, after considerable pruning, about $1\frac{1}{2}$ lb. I allowed 4 lb. for the hull and deck and after making a guess at the weight of the various remaining bits, decided that my displacement must be of the order of 17 lb.

My first idea was to find a yacht in the books of the sort of shape I wanted and to make it on a small scale, but very soon abandoned this scheme, first because it would be more interesting to design my own and secondly because the batteries and motor were of such a size and weight that the hull would have to be designed round them. The former, in fact, would have to act as an internal keel if the boat was to have any stability. The reader can imagine the hours I then spent making sketches, drawings and involved calculations, especially as I was determined to produce a design with "fair" lines and a hull balanced according to metacentric principles, something, incidentally, that I had never heard of a month before, but a subject well worth studying. To digress for a moment, I would strongly advise anyone designing a boat who wishes to make a thorough job of his calculations to beg, borrow or steal (or even buy if it's possible) a planimeter for measuring areas. This will save hours of calculation and is just as accurate as, say, counting squares; it was particularly galling in my case to know that I had one stored with my furniture since before the war and quite inaccessible.

However, after many attempts I finished up with a set of lines which gave me what I wanted, the dimensions being :—

Sailing on a reach with sails undivided

Length overall	39 in.
Length on load waterline ..	32 in.
Beam	8 in.
Draught	$6\frac{1}{2}$ in.
Displacement	$17\frac{1}{2}$ lb.

Fig. 1 shows the profile and Fig. 2 the sections, though these illustrations are merely sketches to show the general form and not accurate reproductions of the actual lines, and in any case my skill as a craftsman is not yet such that I can guarantee that "Peroma" tallies in all respects with the lines of her design, though she is pretty near.

The subject of designing cannot, of course, be a separate phase on a job of this sort, since it is inextricably mixed up with construction, when a great deal of the latter is a case of trying something and then redesigning and trying something else if the first attempt doesn't work.

I would, however, like to mention the control circuit at this stage, since I did reach more or less finality on this before starting on construction. I learnt a major lesson here that no doubt my more experienced readers are quite familiar with, and that is that the first attempt is nearly always much too elaborate, whether it be an electric circuit or a mechanical movement. For example, my first control circuit consisted of a rotary selector switch with four "wipers" and seven relays, and required the wireless receiver to differentiate between two separate frequencies. The final one, which needs only one radio frequency, consists of a rotary switch with one wiper and two relays, the circuit being the very simple one shown in Fig. 3.

The key to the whole thing is the rotary switch which was obtained from a blitzed German automatic telephone exchange and adapted to a continuous rotary movement of one wiper over twelve contacts; the driving magnet, which had to be made to work off 6 volts instead of its original 24 volts, moves the wiper forward one contact each time it receives a current through its coil. Of the twelve contacts, every other one is blank and the remaining six are connected to the motor solenoids, etc., which perform the various functions, shown in the diagram merely as resistances. Of the two relays (from the same source as the rotary switch), relay A is fast operating and closes its contact so long as a signal is being picked up by the receiver; relay B, though operating immediately current flows through it, has a copper slug round the heel end of its coil which prevents it releasing until some 250 millisecs. after the current is cut off. The action is therefore as follows: suppose the rotary switch is to be set as shown in Fig. 3 and it is desired to move the rudder to port, seven short signals are transmitted, and as soon as the first is received relay A closes and completes a circuit from + ve through relay B to — ve; relay B then closes and completes a parallel circuit through the driving magnet which operates and moves the wiper on to the second contact. No current flows to this contact, however, as relay B is operated. During the short gap between the first and second signals the driving magnet releases on the opening of relay A contacts and operates again when the second signal is received. Relay B, however, holds during this gap, and hence the seven signals will step the wiper round to the seventh contact without affecting the functional apparatus passed on its way round.

About 250 millisecs. after the last impulse has ceased, relay B releases, and current immediately flows *via* its contacts to the wiper, and hence to the solenoid which pulls the rudder to port. As soon as sufficient turn has been achieved, one further short signal is sent which breaks the circuit as soon as relay B operates and moves the wiper on to a blank contact. Similarly, if the next thing required is rudder starboard, a further five short signals are sent.

Whether or not this is a standard way of arranging remote control of boats, aeroplanes, etc., I have no idea, but, anyway, it works very satisfactorily, is simple, and there is nothing much that can go wrong.

Construction

By about the beginning of October, I was ready to start building, having collected various bits and pieces of apparatus, made a number of drawings and thought out as much of the design as I needed to start work. In describing the construction, I must necessarily describe the various parts in

turn, but, in fact, their construction overlapped all the way through, depending on how the mood took me; when I got tired of working on the hull, for instance, I would do some work on the wireless side or the control gadgets; so that the whole thing gradually took shape, and any tendency to lose heart when things went wrong was avoided by shelving the problem temporarily and getting on with something else.

Workshop and Tools

I was fortunate in having access after working hours to the carpenters' and fitters' shops of a local unit when such things as planing or lathe work were necessary, but throughout I used them as little as possible, preferring to work in my own room with such tools as I was able to borrow or accumulate by various means. When I did have to use the workshops I had wonderful co-operation from the soldier craftsmen who worked there; they became very interested and gave up much of their leisure time to teach me how to do with the work held in a hand vice or even held between my knees. I would not, of course, recommend the extra labour involved in such methods, but where time is not limited, I do feel that lack of suitable equipment should never deter one from trying a job by improvised methods.

The Hull

I realised from the start that I had neither the materials nor the skill to build the hull by normal boat construction methods. The obvious way to do it was to find a chunk of wood big enough, carve the outside to shape and dig out the inside; but the thought of doing this filled me with horror and I could see no prospect of getting an accurate shape; furthermore, I could foresee most clearly my state of mind when the inevitable happened and I found a chisel protruding neatly through the side of the hull. After much thought, I decided that the only way was to cut out a number of flat layers and glue them together. It will give many of my readers a good laugh to read of this

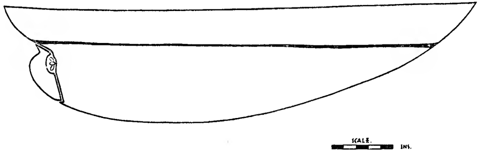


Fig. 1

the various jobs, though I insisted on doing all the actual work for the model myself. It has struck me that there is an instinctive feeling of comradeship amongst people who make things as a hobby; they are always willing to help and advise, to lend favourite tools and instruments, and to be most generous in giving away precious bits of metal from the "junk box." Since I have started reading THE MODEL ENGINEER, I have found that this spirit of helpfulness is common to all model makers, and a very encouraging thought for people like me who hope one day to graduate from novice to better things.

Most of the work on "Peroma" was done in a small spare room in my billet, which contained a bed used as a stand for tools, bits of wood, string, wire, etc., and an old chest of drawers used as a bench. Unfortunately, I had no vice (except a small hand one), plane or drill, but I did own a soldering iron, three or four files, including two Geneva files, one round and one flat, both with the ends broken off but still serviceable; I also had a hammer, some pliers and screwdrivers, a penknife and, most valuable, some hacksaw blades. At a later stage, after a visit to England on leave, I bought a small hacksaw and borrowed a hand drill, but previously I had done a vast amount of sawing of both wood and metal, using a hacksaw blade gripped with a piece of rag and wonderful idea of mine, but I had never taken an interest in such things before and it wasn't until much later that I discovered that this "bread and butter" method was a standard practice amongst model boat builders.

The only wood I could find was ¼-in. 5-ply sheets which had previously done service as notice boards. One of them, incidentally, had a Union Jack painted on it and "Army Signal Office," and had been used to mark that office during the Potsdam conference—so "Peroma" contains some historical material! As will be seen later, ply wood is not ideal, but if nothing better is available, it certainly can be used satisfactorily. The method I used was as follows:—

First I drew full size and as accurately as I could on squared paper, the half-breadth waterlines at ¼-in. intervals for the whole hull from top to bottom, a total of 44 layers. I then placed the paper on the wood with double-sided carbon paper between, pinned down at each end on the centre line, and drew round the appropriate line with a hard pencil. I then turned the paper over, put the pins back in the same holes, this time with a single-sided carbon paper on the wood, and drew round the carbon line which the first operation had produced on the back of the paper. Thus I got on the wood a carbon line marking the outside edge of the top of the particular layer and

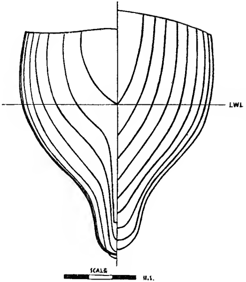


Fig. 2

knew that the two halves were quite symmetrical. With my faithful hacksaw blade I then cut out the layer, leaving about $\frac{1}{16}$ in. spare all round, and then smoothed it down to the carbon line with sandpaper. I was able to save a lot of time in this latter process and also in the latter work on the hull, by using a rotating band of sandpaper which I discovered in use in a local furniture factory.

Having cut out and smoothed to shape all the layers, I then placed each in turn, starting with the smallest, on the next larger and drew a pencil line round it, having, of course, first made sure that the smaller was in the correct relative position on the larger layer. This line gave me the outside edge for the bottom of the larger layer. I then drew another line $\frac{1}{8}$ in. inside this one, which gave me the inner portion of the layer which could be cut away, and would ensure that at least $\frac{1}{8}$ in. of surface would be available for gluing. Before cutting away the centre, I adjusted this inner line to give me the various shelves I needed for mounting apparatus, and in certain cases left cross bars for strengthening the hull or, again, for positioning such things as the batteries. Each layer had been carefully lettered as I went along, and Fig. 4 gives an example of this process.

The next job was to glue the layers together, and this I did in groups of about six layers, often mounting apparatus within the various groups as I went along, which would have been difficult to get at if the hull had been completed in one operation. I had been fortunate in that during a visit to London I had spotted a synthetic waterproof glue in a ship chandler's shop window. This glue (called Casco) is really excellent, and has the enormous advantage of being a powder which is mixed with cold water when required for use and applied cold. Cramps were not available, but I found that a marble-topped table turned upside down and balanced precariously on top of the group of layers being glued, was the perfect answer, and I had no difficulty in getting satisfactory joints; as a precaution, I subsequently poured any glue made up and left over inside the hull and let it run round the joints.

Before joining the groups together, the outside of each section of hull was roughly shaped by cutting or rather smoothing away the lower edges of each layer. I believe the best way to do this would be by using small planes, preferably with curved blades, and both convex and concave surfaces would be needed. However, I had no such things available, and did the job on the moving band of sandpaper mentioned above; this was quite satisfactory for long, even curves, but was tricky business where curves changed direction sharply. In this initial process I left a small amount of wood at each joint to be taken away in the final smoothing, which was done after all the groups had been glued together, again using the moving band and finishing off by hand with sandpaper. Fig. 5 illustrates this process.

(To be continued)

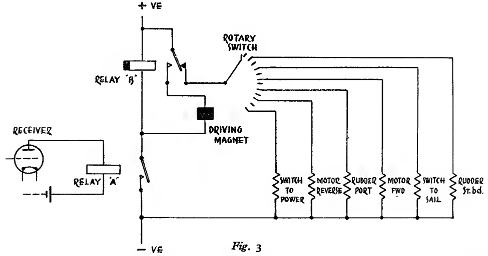
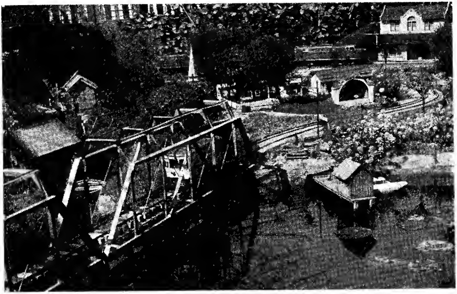


Fig. 3

The HOWARD BROTHERS



Santa Fe LINES

(1) *Model streamliner passing the Wildwood station and village, as seen from across the village pond*

(2) *A Santa Fé streamliner freight passing the junction of Roseland on the outskirts of the village of Wildwood*

(3) *The model streamliner passing the colourful setting of "Mission San Antonio," in Texas*

General Outline

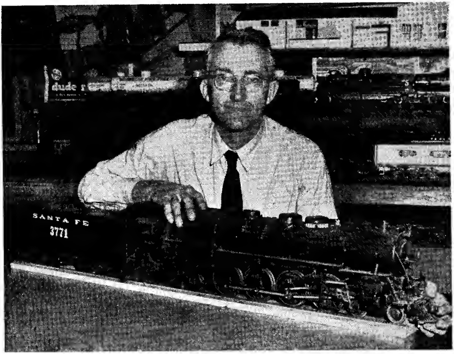
WHO.—H. R. Howard, public school teacher and founder of the Pomona Model Yacht Club, later the Pomona Hobby Club, a model club for boys and their fathers, as well as older men.

WHAT.—Builder of model trains and settings of the Santa Fé railroad; ½-in. scale. Brother H. S. Howard designs and builds all controls and electrical work.

WHEN.—This is the fortieth year of model railroad building for H. R. Howard and the eighteenth year of specialising in controls, sound and electrical effects of model railroading for the brother Homer S. Howard.

WHERE.—232, E. Jefferson St., Pomona, California.

WHY.—As a hobby.



(4) H. R. Howard and $\frac{1}{2}$-in. scale model of a Santa Fé steam locomotive

General Information

ALL model work is done by H. R. Howard, public-school teacher, and all electrical work and controls designed and built by Homer S. Howard, electronics engineer, and brother to H. R. Howard. The model railroad is known as the "Howard Brothers' Santa Fé Lines."

As a public school teacher, H. R. Howard has taught auto mechanics, wood and sheet metal work and leathercraft in schools and institutions of Pomona Valley.

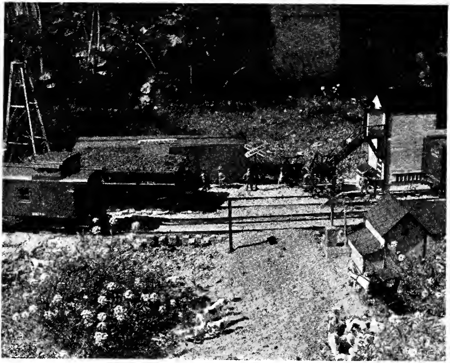
Models are half-inch scale, built to withstand the elements and rigours of out-of-doors. Buildings are set on a cement foundation, and the streets are paved with asphalt and concrete. All shrubbery is in miniature, from the shade trees to tiny rose bushes with tiny blooms less than three-fourths of an inch across.

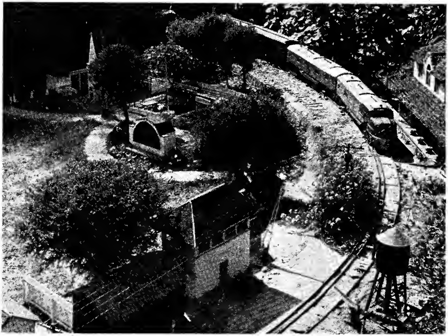
Buildings, streets, and rolling stock are electrically lighted. Wires are strung on regular poles to carry currents from six volts and up a.c. and d.c. Smoke is made to roll from the chimneys of the shops and from the forge of the village blacksmith. By electronics, hymns are to be heard coming softly from the country church, or the beat and roll of a lusty march from the village bandstand, and even music or announcements from the lounge car of a passing passenger train.

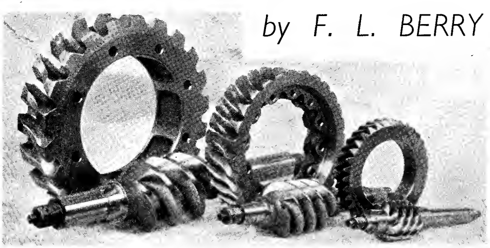
(To be continued)

(5) The country crossing of "Mission Junction," with farmers waiting for the freight and passenger trains to arrive. A rural setting with horse and buggies and cattle, with the freight house and control tower in the background

(6) Daylight picture showing streamline freight passing the village station with the community centre lying in front of and across the tracks







by F. L. BERRY

WORM GEAR
PRINCIPLES AND NOTES

FIFTY years ago leading engineers stated that while worm gear had many good points, it would never be successful for transmission work, owing to its heavy friction losses. Since then much has been done by way of research and development on this gear, and today it is universally employed for transmission work and automobiles ; even the War Office experts have been converted to its use, and it is used on their heavy trucks.

In view of its general adoption, it is surprising to find so much confusion and vague ideas of its principles and terms. One man speaks of "pitch" when he means "lead," another talks of single and double threads, while his mate talks of two- and three-start worms, the more sophisticated draughtsman thinks in terms of multiple threads, and lead angles. All of which, when clarified, mean much the same thing.

Terms

The "pitch" of a worm or any screw is the distance from a point on one tooth, to a corresponding tooth on the next, measured axially, and this definition holds good no matter how many threads the worm may have. The "lead" is the distance the worm will advance per revolution if screwed through a fixed nut. Only in the case of a single threaded worm does the lead and pitch mean the same thing. Lead is a main factor in the efficiency calculations. Pitch is the basis upon which teeth are proportioned, and power calculations made.

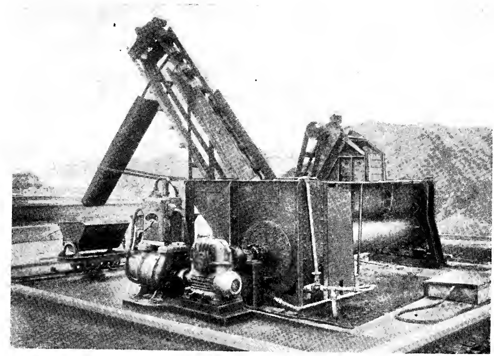
Core Diameter

One important element in a worm is the diameter at the bottom of the teeth, and is known as the core diameter. This core has to transmit the power, deal with the torque and end thrust, and resist bending stresses which might cause deflection in action, undue deflection being fatal to good running of the gear. At first sight there seems no reason why this core should not be made on the strong side to give ample strength to the gear. But there are reasons why it should be kept as small as possible consistent with the necessary strength, and it is partly in this connection that small teeth instead of large ones are used in worm gear.

Lead Helix

Tied up with the core diameter is the angle of the lead helix, which largely determines the efficiency of the gear, and it is determined by the pitch circle of the worm, which again is governed by the core. Take the pitch circle diameter of the worm and assume that a point in it traces out an angle as it winds its spiral way around the worm. Take the circumference of the pitch circle as a base line, and the lead as the tangent or vertical ordinate, then join up the two ends and the angle enclosed in that of the lead helix.

The lead helix, in conjunction with the coefficient of friction between the teeth of worm and wheel, determines the efficiency of the gear, and while the angle is kept small and flat, it



R.H.U. type Radicon worm reducer applied to a sand-washing machine

can never give high efficiency, no matter how good the co-efficient of friction may be, and will always be inferior in this respect to one with a steeper angle.

There are times, however, when a flat angle is preferable; such a case occurs in electrically driven lifts, in which a flat angle worm will hold the lift at any stage without any help from brakes, it acts automatically each time the power is cut off, and is of tremendous power. The very fact that it will so hold the load indicates that as a means of transmitting power it would be unsatisfactory.

Teeth

In order to get a good steep angle the worm is kept as small as possible, and the use of small teeth enable it to be kept to the minimum diameter. If teeth of larger size were to be used, the core diameter would require to be enlarged, a larger diameter of worm would result, and the whole set would be much heavier, with larger bearings, housings and gear generally and more space would be required, in automobile work space is of first consideration.

Revolving Wedges

In order to follow the working of the lead helix, assume the worm to be a series of revolving wedges, of which each thread is one. These wedges transmit power by rotating the driven wheel to which is connected the driven shaft. A single threaded worm would rotate the wheel a distance equal to the pitch per each revolution, of the worm. By fitting several threads to the worm the lead would be increased, and the work done per revolution several times as much. The diameter of the worm, however, would remain the same, hence the extra work would be done by a very little cost by way of extra friction, the loss in this respect per revolution being proportional to the length of the friction line, which in this case equals the circumference of the pitch circle diameter of the worm.

This may be easily followed. Consider a weight being pushed up a ramp or incline of 10 degrees, to a height of 5 ft., the angle of the ramp represents the angle of the lead helix. Now increase the angle to 20 degrees and run the weight up to 10 ft., thus doing double the work, while the only extra cost in friction losses is the difference in length of the hypotenuse of the lead or ramp angle, and the gain by using steep angle leads is obvious.

Theoretically, efficiency increases until the angle of 45 degrees is reached, but only in special cases is this angle approached, but worm gear has its limits beyond which it is not advisable to go without special reasons, as by so doing other advantages lost will more than offset any gains, and while efficiencies of 94 per cent. may be obtained by angles around 25 to 30 degrees, there is no point in going to extremes.

Examples

One example which has now been running for years, is a five-threaded work with a 29-degree angle, which gives an efficiency of 94 per cent. with a reduction ratio of 20 : 1, and a rubbing speed between the teeth of 1,100 ft. per minute. A worm with a 23-degree angle gave 92 per cent. efficiency with a reduction of 10 : 1. A double threaded worm, running at a rubbing speed of 1,100 ft. per minute, with a 17-degree angle, gave 80 per cent. efficiency, with a reduction ratio of 20 : 1.

Rubbing Speed and Co-efficient of Friction

Tests by British, American, and Swiss engineers confirm the fact that as the rubbing speed increases the co-efficient of friction is reduced very consistently. Around 200 ft. per minute may give a co-efficient of 0.040, the same worm at 500 ft. shows an improvement at 0.030, while at a speed of 1,100 it clocks up at 0.022, and is still improving as the speed increases.

Cooling of Oil

The friction loss is largely governed by the temperature of oil in the gear case, too cold an oil, or too high a temperature are both against good results, but while too low a temperature will lower the efficiency, the effect of too high a temperature is much more severe. One of the major problems in this respect is to maintain an oil film between the gear teeth, when this is destroyed, abrasion and general deterioration of the surface is set up, then the load may be reduced by as much as a third or a half of its capacity. A working temperature of 140 to 160 degrees F., is aimed at, and to assist in the dispersal of heat radiation fins are cast on the gear boxes. Not only is the heating most important, but the use of a suitable oil is also of first importance.

Materials

The best is not too good, and the brand of special steel best suited for particular conditions is used for the worm, which is ground after case-hardening. The worm wheel rim is of bronze, centrifugally cast, this ensures a dense uniform metal throughout. The rim is mounted on a cast-iron or steel centre.

Speed Reduction

One of the great advantages of worm gear is its capacity to effect in one stage a large reduction of speed, with one pair of gears. The reason why this is so, lies in the fact that in effect a worm is a pinion with an abnormally small number of teeth, a single threaded worm has its opposite number in a spur pinion of only one tooth, while a six-threaded worm is equal to a pinion with six teeth, hence, the possibilities in this respect. A single-threaded worm geared to a wheel with 30 teeth would have a reduction ratio of 30 : 1, while the six-threaded worm would give a ratio of 5 : 1. If extra large reductions are required, two sets of worm gear housed and mounted in the same gear case is the answer. As the gear is boxed up and dust-proof and free from grit, the life is long, and the gears are silent and self-contained, and particularly suited for gritty sites where spur gear are not always too good, all that is wanted to get the best out of worm gear is attention to the oil and the usual supervision. As a sample of reliability, mention may be made of a set running under bad conditions, which for several years ran 130 hours per week without trouble or stoppages.

A BASSETT-LOWKE SHOWROOM EXTENSION

AN encouraging sign of the increased public interest in models of all kinds is apparent in the addition to their London showroom, which Messrs. Bassett-Lowke Ltd., have recently opened. At this popular rendezvous in High Holborn, the window display has been doubled by the acquisition of the adjoining premises, and a new and attractive interior showroom has been installed which will enable a much more complete range of model goods to be shown to advantage. The official opening of the new premises was made the occasion for a friendly little gathering of the principal members of the staff, and representatives of the model engineering and railway press. Mr. Cyril Derry, the Chairman of the Company, in declaring the new showroom formally opened for business, gave an interesting summary of the founding and development of the firm, and paid a cordial tribute to his colleagues on the Board and the staff for their unfailing enthusiasm in the interests of the Company and the model-making public. He extended a special welcome to their friends of the press who had accepted an invitation to attend on this occasion. Mr. Percival Marshall, who responded on behalf of the visitors, congratulated the firm on their new enterprise, and said their reputation for being up to date in their designs was such that he could imagine the locomotive engineers of the principal railway companies coming down to Holborn to see if the latest model locomotives had any novel features which they might incorporate in the new engines they were preparing to put into service. In proposing the toast of success to the Company, and to the new showroom, he complimented the firm in having, through their fascinating catalogue, provided all the schools of the country with one of their most popular text-books. Among those present were Mr. W. J. Bassett-Lowke, Mr. Cecil J. Allen, Mr. J. N. Maskelyne, Mr. Franklin, Junr., Mr. F. C. Forman, Mr. Kahn, Mr. F. J. Camm, Mr. Colman, Mr. D. A. Russell, and Mr. Bert Sell.

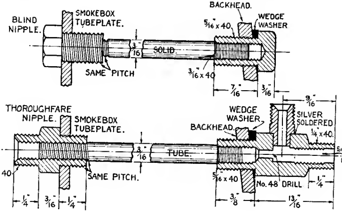
Stays for "Hielan' Lassie"

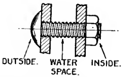
By "L.B.S.C."

FOUR longitudinal stays are required, three being solid rods, and the fourth a piece of heavy-gauge tube which carries steam for the blower. The three solid rods are $21\frac{1}{2}$-in. lengths of $\frac{3}{16}$-in. round copper, screwed about $\frac{1}{2}$ in. each end. If your lathe has a hollow mandrel, hold the rods in the three-jaw and use a $\frac{3}{16}$-in. by 40 die in the tailstock holder; if not, screw by hand with the rod held in the bench vice, but get the threads as true as possible. If the thread is wobbly, or "drunken," as the shopmen call it, the end of the stay will be strained when screwing on the blind nipples, and its staying power seriously reduced. Don't forget a drop of cutting-oil ensures clean threads. The blind nipples are shown in the accompanying detail sketch, included for novices' benefit. Chuck a bit of $\frac{3}{8}$-in. hexagon brass rod in three-jaw; face, centre, drill down with No. 22 or 5/32-in. drill for about $\frac{1}{2}$ in. depth, and tap $\frac{3}{16}$ in. by 40. Turn down $\frac{7}{16}$ in. of the outside to $\frac{5}{16}$-in. diameter, screw $\frac{5}{16}$ in. by 40, and part off to leave a head about $\frac{3}{16}$ in. in thickness. Reverse, and chamfer the corners of the hexagon.

I put the tap in the drill chuck, and turn the drill spindle by hand; a spot or two of cutting-oil on the tap, and there we are, all present-and-correct-sergeant. If you haven't a drilling machine at all, or one that is too small to admit the boiler between chuck and table, the only thing to be done is to drill and tap by hand, taking care to keep the drill brace parallel with the boiler barrel when drilling, and using a tap with a long taper to start the thread in the hole. It will be found anadvant geto drilla pilot-holefirst w.th a No. 30 or $\frac{1}{8}$-in. drill, and follow up with the tapping size, viz. 9/32 in. Tap $\frac{5}{16}$ in. by 40.

A wedge-shaped washer will be needed under each nipple-head at the backhead end, as shown in the illustration; these are simply slices parted off a drilled $\frac{3}{8}$-in. brass rod held in three-jaw and filed to the necessary taper. To insert the stays, screw one of the nipples on to one end for about three threads, and put a wedge washer over the thread on the nipple. Put a piece of thin $\frac{1}{4}$-in. tube on the other end, which should be a tight push fit; the exact length doesn't matter. Insert the tube through the hole in the backhead, and





Boiler stays for "Hielan Lassie"—(top) solid long; (centre) hollow long; (bottom) firebox stay

Set out four points on the backhead, corresponding to the four shown on the drawing of the smokebox tubeplate; but instead of drilling them at right-angles to the tubeplate as usual, they have to be drilled parallel with the boiler barrel. As I have a pillar drill, naturally I find this quite easy, as all I have to do is to up-end the boiler on the driller table, standing it on the smokebox end, and poke the drill straight through the centre pops, which are made very heavy. When tapping,

push the stay through after it, until you feel the tube come up against the smokebox tubeplate. A little judicious juggling will then be called for, to get the end of the tube through the corresponding hole in the smokebox tubeplate; but, once through, screw the nipple at the backhead end right home, adjusting the washer to allow perfect contact between it, the nipple head, and the backhead. The tube can then be pulled off the stay at the smokebox end, leaving three or four

threads of the stay projecting through the hole. Screw on another nipple, and this will also engage with the tapped hole, so that when the nipple is right home, the whole issue is locked solid. A smear of plumbers' jointing on the threads will ensure steam-tightness.

The hollow stay is $\frac{1}{4}$ in. longer than the solid ones, and is made from $\frac{3}{16}$-in. by 16- or 18-gauge copper tube. Screw both ends $\frac{3}{16}$ in. by 40 as above, but put about $\frac{3}{4}$ in. length of it on one end, and $\frac{1}{4}$ in. on the other. The blower valve is attached to this end. To make it, chuck a bit of $\frac{3}{8}$-in. hexagon brass rod in three-jaw; face the end, centre, drill down a full $\frac{1}{4}$ in. with 5/32-in. or 22 drill, and tap $\frac{3}{16}$ in. by 40. Turn down $\frac{3}{8}$ in. of the outside to $\frac{5}{16}$ in. diameter, screw $\frac{5}{16}$ in. by 40, and part off $\frac{13}{16}$ in. from the shoulder. Reverse in chuck; turn down $\frac{1}{4}$ in. of the outside to $\frac{1}{4}$-in. diameter, and screw $\frac{1}{4}$ in. by 40. Centre, drill right through with No. 48 or 5/64-in. drill; open out to about $\frac{1}{2}$ in. depth with No. 30 drill, and bottom the hole to $\frac{5}{8}$ in. depth with a D-bit. Open out further with No. 21 or 5/32-in. drill, for about $\frac{1}{8}$ in. depth, and tap the rest of the No. 30 hole with a 5/32-in. by 32 tap if you have one; if not, use 40, but a coarser thread gives quicker action to the valve, which is an advantage on the road. Drill a $\frac{3}{16}$-in. hole at $\frac{1}{4}$ in. from the shoulder, in one of the hexagon facets; and in this fit and silver-solder a $\frac{1}{4}$-in. by 40 nipple, as shown. Chuck a bit of $\frac{1}{4}$-in. round brass rod in three-jaw; face the end, centre deeply using size "E" centre-drill, and drill down about $\frac{3}{8}$ in. with No. 40 drill. Screw the end for about $\frac{1}{4}$ in. length with $\frac{1}{4}$-in. by 40 die in tailstock holder; part off a full $\frac{5}{16}$ in. from the end, reverse in chuck, and turn $\frac{1}{16}$ in. of the plain end to a tight squeeze fit in the hole in the side of the blower valve.

The nipple on the smokebox end of the stay is a "thoroughfare" one. Chuck a piece of $\frac{3}{8}$-in. hexagon brass rod in the three-jaw; face, centre, deeply with a size "B" centre drill, turn down $\frac{1}{4}$ in. of the outside to $\frac{5}{16}$-in. diameter, and screw $\frac{5}{16}$ in. by 40. Part off at $\frac{11}{16}$ in. from the end; reverse in chuck, and ditto repeato the turning and screwing process. Drill right through with No. 22 or 5/32-in. drill, and tap $\frac{3}{16}$ in. by 40.

Screw the hollow stay into the end of the blower valve, not forgetting a taste of jointing paste, and put on a wedge washer. Put a bit of wire down the tube, or use the extension, same as with the rod stays; then insert in the extreme right-hand hole in backhead. Wangle the extension tube or wire through the corresponding hole in the smokebox tubeplate, pull it away, screw the blower valve right home, so that the nipple on it points skywards, and put on the thoroughfare nipple. You need not wrench them up tight enough to strip the threads (beginners usually do!), as the usual brands of plumbers' jointing, such as Boss White, make a perfectly steam-tight seal with quite moderate tightness.

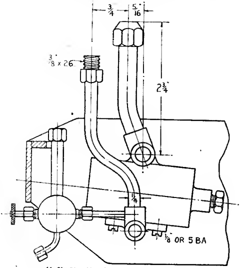
Firebox Stays

The job of staying a firebox is, in your humble servant's estimation, the most monotonous part of the whole doings, though some of my old munition girls would have loved it. They work differently from boys. With a cup of tea alongside the machine, they would have drilled and tapped all the holes, made the staybolts, screwed them home and nutted them, quite automatically, whilst their minds were far away with boy friends, dances, pictures, or pretty frocks. I go to work in exactly the same way, doing the job automatically whilst I daydream about childhood, with sweet oranges at six a penny, dates at twopence a pound, and boiled sweets at a halfpenny more; or else my spirit takes a run on *Wigmore* or *Purley*, with an evening suburban train, first stop Norwood Junction in 13 mins. from London Bridge, or maybe works the Thursday afternoon "Early Closing" excursion to Brighton with old *Fairlight*, hauling sixteen four-wheeled "cattle-box" thirds, with straphangers in every compartment and all the springs out straight, sailing into the terminal in very nearly "even time" by aid of one solitary pair of driving wheels plus a little sand and "common savvy." Happy days!

Getting back to present realities, there are 21 stays in each side of the firebox, 7 in the throatplate and 8 in the backhead. The position of all the holes is shown on the longitudinal and cross sections of the boiler already published. Drill them with No. 30 drill, clean through both outer and inner plates, and tap either with a tap having a very long taper or a pilot pin. You can make either at home, from a bit of 5/32-in. silver-steel either turning a long taper, or a pilot pin which will just enter the No. 30 holes, long enough to project just through the firebox plate before the thread starts to cut. Screw sufficient of the steel at the end of the pilot pin or taper to span both plates, say, $\frac{5}{8}$ in.; if unable to flute the screwed portion, file four flats on it. Harden and temper to dark yellow, and use with plenty of cutting-oil. A squared tap won't cut such a perfect thread as a fluted one, so if you square yours, run an ordinary second tap through the holes afterwards.

The staybolts are made from soft copper rod. The finest stuff I have ever used—and am still using—is obtained by unravelling the strands of scrap ends of high-tension electric cable (Milly Amp isn't shy of helping her steam friends!) This wire is high-grade copper, ductile, and takes a lovely thread. If ordinary commercial copper rod is used, soften it; cut up into about 4-in. lengths, make them red-hot, drop into your pickle bath, and well wash in running water. This cleans them as well as softens them. Screw each end of each piece for about $\frac{5}{8}$ in. length with a die in tailstock holder. There are no commercial brass lock-nuts tapped 5/32 in. by 40, so these will have to be home-made. Chuck a bit of $\frac{1}{4}$-in. hexagon brass rod in three-jaw; face, centre, and drill down for $\frac{5}{8}$ in. or so with No. 30 drill. Tap 5/32-in. by 40, and part off three $\frac{1}{8}$-in. slices. Ditto repeato until you have about half a gross; a few spares will come in mighty handy. They should be chamfered both sides. Chuck a bit of $\frac{1}{4}$-in. round rod in the three-jaw; turn down $\frac{1}{8}$ in. of the end to 5/32-in. diameter, and screw it 5/32 in. by 40. Screw each nut on this, and touch the corners of the hexagon with a square-ended tool ground off obliquely at one corner. Sounds a long job to do the lot, but you can do it automatically whilst thinking about filling up your football pool coupon or doing a crossword puzzle!

Screw a tap-wrench in the middle of the stay rod, between the two portions of thread, and this will enable you to screw the threaded end of the rod through both plates until it beds tightly into the tapped hole in the outer plate of the boiler. Snip off the rod about 3/32 in. from the plate, put a nut on the inside, and tighten it with one of the box-spanner gadgets which I described a short while ago. The bit of rod can be re-screwed



" Juliet " pipes and lubricator

for two more stays. When you have got all the lot in—and it won't take as long as you anticipate —put a bar of iron in the bench vice, projecting sideways from the jaws. Rest the inner end of each stay on it whilst you head over the outer end with the ball end of the hammer head. When through, give all the nuts a final nip up, and the job is complete.

How to Sweat Up Heads and Nuts

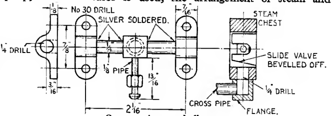
By the good rights, if the stays are screwed without torn threads, and the tap doesn't "cut large," the stays should fit steam-and-water-tight in the copper plates, and require no further treatment. However, to make assurance doubly sure, it is always advisable to sweat over all the heads and nuts with solder. Plumbers' solder is the best, as it has a higher melting point than ordinary tinman's solder, although the latter will do quite well if the former is not available. For this job your small blowlamp will come in handy; you also need a copper bit (soldering-iron), some liquid flux, and a small wire brush. Once more a warning: don't on any account use a paste soldering flux for boiler work. Paste fluxes may be all right for certain jobs, such as mending pots and kettles, and electrical connections; but I have yet to find one that is satisfactory for our purposes. Once any trace of it gets inside the boiler, you'll never get rid of it, and the gauge glass will emulate Ananias "for ever and aye." Also, a liquid flux will wash off any dirt or oxide that paste flux won't look at. Any of the good proprietary fluxes, such as Baker's fluid, will do, or you can make your own by dissolving zinc in muriatic acid (spirits of salts) until it won't take any more, and then adding a little sal ammoniac. Lump chloride of zinc, dissolved in water, is also O.K. Manufacturing chemists sell it. The wire brush can be home-made by tying a bundle of fine iron wires on the end of a stick.

Lay the boiler on its side in the brazing pan, and brush some flux over all the stay-heads and nuts on the "up" side. Heat the boiler to the melting point of the solder, with the blowlamp, and touch the stayheads and nuts with the solder stick, or melt off a little between the heads and nuts. Then, keeping up the heat, dip the wire brush in the flux and apply it to each head and nut, which will cause the melted blob of solder to run all around it. Alternatively, melt up a little pool of solder between the heads and nuts, and brush it over all the lot. This is especially suited for doing the nuts inside the box, as the melted solder can be brushed completely over the surface, covering rivet heads and joints as well, so that if a beginner has a doubtful spot in his brazing or riveting, the solder will seal it. Keep dipping the brush in the flux all the time. If the solder refuses to run around one particular stay, apply the hot soldering-bit in the blowlamp flame, and some extra flux and solder. That will teach it manners! When every head and nut is covered, inside and out, let the boiler cool until the solder sets, then give it an extra good wash, inside and out, to remove all traces of flux. Next stage, testing.

"Juliet"

Steam and Exhaust Pipes

Whether a mechanical or displacement lubricator is used, the arrangement of steam and



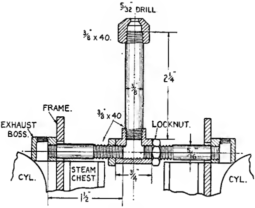
Steam pipe and flanges

exhaust connections is as shown in the accompanying illustration. For displacement oiling, the underneath connection to the steam chests is necessary, as oil won't run uphill of its own accord, which rules out a top connection; and the accessibility is useful if a beginner ever wants to dismantle the cylinders without removing the boiler, which, with the arrangement shown, is easily done. For mechanical lubrication, a clack or check-valve is added to the tee on the cross pipe below the steam chests.

The exhaust pipes should be put in first. Castings will be available for the tee piece; chuck by one end, set the other to run truly, face, centre, drill right through with 9/32-in. drill, and

tap $\frac{5}{16}$ in. by 40. Screw the faced end on to a stub of rod in the chuck, turned down and screwed to suit, and face off the other end. Chuck in four-jaw, with stem outwards and set to run truly; face, centre, drill with an 11/32-in. drill into the cross passage, and tap $\frac{3}{8}$ in. by 40. Run the $\frac{5}{16}$-in. tap through the cross hole again to remove any burrs. Make two $\frac{5}{16}$-in. by 40 lock-nuts, as described above for "Lassie's" stay nuts.

Cut two pieces of $\frac{5}{16}$-in. copper tube to a length of $1\frac{1}{2}$ in.; screw one end for $\frac{3}{16}$ in. length and the other for $\frac{5}{8}$-in. length, $\frac{5}{16}$ in. by 40. Put a lock-nut on each longer end, and screw them into the tee until they touch in the middle; hold the



Exhaust pipes

tee midway between the cylinders, opposite the exhaust holes, then screw the pipes out of the tee, into the holes in cylinders, finally tightening up the lock-nuts against the tee. Note, the stem of the tee is inclined slightly forward, as shown in the side view.

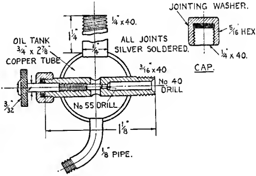
The blastpipe is a $2\frac{1}{4}$-in. length of $\frac{3}{8}$-in. copper tube, screwed at both ends $\frac{3}{8}$ in. by 40, and bent slightly, as shown, so that its centre-line is $\frac{1}{16}$ in. ahead of the centre of the cross pipe. To make the nozzle, chuck a piece of $\frac{7}{16}$-in. hexagon or round brass rod; face, centre, and drill about $\frac{5}{8}$ in. deep with a 5/32-in. drill. Open out to $\frac{7}{16}$ in. depth with 11/32-in. drill, tap $\frac{3}{8}$ in. by 40, and part off a full $\frac{1}{2}$ in. from the end. Reverse in chuck, and turn the top slightly coned, as shown. Screw it on the blastpipe to full depth of thread. No jointing material is needed on exhaust pipes.

Assembly

The steam pipe assembly is simplicity itself, as no screwed joints are needed in the pipes at all. The two flanges for attachment to the steam chests can either be castings or filed up from $\frac{1}{2}$-in. square brass rod. The cross hole in the tee is drilled $\frac{1}{4}$ in., and the stem same size. The $\frac{1}{4}$-in. cross pipes are fitted tightly into both tee and flanges, and a 3-in. length of $\frac{1}{4}$-in. pipe, bent as shown in the side view, is fitted into the stem of the tee. A union-screw is fitted to the top of the cross pipe; to make it, chuck a piece of $\frac{7}{16}$-in. hexagon rod in three-jaw. Face, centre deeply drill down $\frac{5}{8}$ in. depth with 7/32-in. drill, turn down $\frac{1}{4}$ in. of the outside to $\frac{3}{8}$-in. diameter, screw $\frac{3}{8}$ in. by 26, part off $\frac{1}{2}$ in. from the end, reverse in chuck, and open out $\frac{1}{8}$ in. of the other end with a $\frac{1}{4}$-in. drill. Press it on as shown. Drill a $\frac{1}{8}$-in. hole in the tee, and fit in it a $\frac{3}{8}$-in. length of $\frac{1}{8}$-in. pipe with a union-nut and cone on the end. The whole of the joints—side flanges, tee, and steam union—can then be silver-soldered at the one heat. Pickle, wash off, and clean up.

Clean Passages

Drill a $\frac{1}{4}$-in. hole in the bottom of each steam-chest, right in the centre, between the two middle fixing-screws. You'll have to take the steam-chests off to do this, naturally, so whilst they are off, bevel off the lower side of each slide-valve, to allow the steam free entry into the steam-chest whilst the valve is moving back and forth above the holes. Temporarily replace the steam-chests, and, with the chassis upside down on the bench, put the steam-pipe assembly in position. Run the No. 30 drill through the holes in the flanges, making countersinks on the steam-chests. Remove, drill out the countersinks with No. 40 drill, and tap $\frac{1}{8}$ in. or 5 B.A. The whole bag of tricks can then be assembled as shown, using oiled paper gaskets between the contact surfaces; but, before doing so, make certain there are no drillings, chippings, or any unauthorised oddments left in the steam-chests, passages or pipes. I remember a case where a fitter who wasn't exactly as careful as he might have been, left a small cold chisel in the steam-chest of one of our goods engines. Nothing happened until the engine ran through a junction at a fairly good clip, and shook herself up a bit; then—well, they had to send out the tool van, disconnect the "works," and pull her

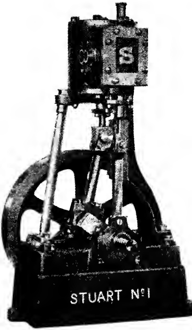


Section of displacement lubricator

home. I took a look inside the steam-chest when the cover was taken off, and one could hardly realise that the torn and damaged portfaces, bent spindles and broken buckles were caused by a bit of steel the size of your little finger. The next instalment will deal with the alternative methods of lubrication, displacement and mechanical, and you can "take your pick," as the kiddies would say.

By K. N. HARRIS

Reconstructing A STUART-TURNER No. I ENGINE



The original standard engine

THE Stuart No. 1 has always been a favourite of mine; it is not only a sound piece of engine design, but it has an historic interest, inasmuch as it may fairly be said to be the engine from which the world-wide business of Stuart-Turner Ltd., originated.

Quite recently, one of these engines came into my possession, and I decided to strip it, recondition it, and add quite a lot of things to it.

Generally speaking, the original workmanship was good, particularly with regard to machine work. As an example, the cylinder bore dimensioned at 2 in., on being most carefully checked, showed no departure from this figure greater than + 0.0004 in., — 0.0000 in.

The engine was a number of years old, and had evidently done an appreciable amount of work, wear was perceptible in the main bearings, big and little ends; the piston rod, through having been left standing with water in the cylinder presumably, was badly corroded. The piston ring had completely lost its radial pressure.

The first job was to strip everything right down and decide what wanted replacing.

On the face of it, the piston ring, piston rod, and gudgeon pin were the only major items, though as subsequent events proved, certain other items had eventually to be renewed too.

There were a number of slot headed screws in use and some of the bolts and nuts were the worse for wear, these were scheduled for renewal in due course.

The next item was to decide on the alterations and additions, and to make the necessary drawings. As the engine is quite big enough to drive a small canoe or punt, I decided to modify it suitably, and obviously the first item was a reversing gear, further, the large $7\frac{3}{8}$-in. diameter flywheel and the auxiliary box bed were quite out of place.

The additions and alterations finally arrived at were as follows:

1. Fit link motion reversing gear.
2. Fit balance weights to crankshaft.
3. Fit small diameter balance wheel in place of large flywheel.
4. Fit sub-base suitable for mounting on bearers.
5. Install complete lubrication arrangements for all important bearings.
6. Fit screw-down stop valve to steam supply.
7. Fit displacement cylinder lubricator of large capacity with separate condenser coil.
8. Fit combined auto and hand controlled drain valves.
9. Re-lag cylinder body and supply lagging cap to cylinder top cover.

Drawings were made of all these items.

Photograph No. 1 shows a Standard Stuart No. 1. Photographs 2 and 3 show the engine in course of preliminary erection, and Photographs 4 and 5 show the finished job. Photograph No. 6 shows some of the "discards."

After stripping down, the first job was to open up and square the ports and recondition the surface of the port face.

The ports had been left pretty well as cored, and although not bad, were neither as wide nor as cleanly aligned as they might have been; this, of course, was quite easily remedied. The port face was scraped up to surface plate. Incidentally it is a great advantage to have the port face independent and standing slightly proud of the surrounding surface, this is not done in the Stuart No 1, and in consequence, the whole area has to be re-surfaced to take care of any wear on the portion over which the valve works, which adds a lot to the work involved. No doubt this is done in the case of the Stuart to simplify primary machining operations, which, of course, it does.

The modifications to the ports involved a new slide valve. This was made as a built-up job from hard rolled brass, so hard in fact, that cutting lubricant had to be used in drilling it.

The new valve gear gave more lap and deeper and wider exhaust cavity.

It was planned to increase its travel as much as possible (about 16 per cent.), and the steamchest was slightly opened out endways to allow for this.

The valve setting for full gear is as follows :—Travel, $\frac{7}{16}$ in.; lap, 7/64 in.; port opening, 7/64 in.; lead, nil; exhaust line and line cut-off, 75 per cent.

If an engine is properly designed and made as to its steam and exhaust ports and *passages*, its slide valve (adequate depth to the exhaust cavity is important) its valve gear and its exhaust pipe, there is no need to provide exhaust clearance, in fact, it is a definite disadvantage.

The piston speed of a Stuart No. 1, at 1,500 r.p.m., is only 500 ft. per min.; in a modern passenger locomotive it may not infrequently rise to 2,000 ft. per min., four times as fast, yet the C.M.Es. of our four great trunk lines do not find it necessary to provide exhaust clearance in connection with their valve arrangements.

It has been said, not without truth, that the necessity for providing exhaust clearance is a direct indication of faults elsewhere in the design of the apparatus controlling the steam cycle.

Reverting for a moment to the slide valve itself, this consisted of the main body, a cover, and two lugs to act as abutments for the driving nut. The whole was pegged together with brass pegs and silver-soldered with "Easyflo."

The valve spindle was made on the differential thread principle with a view to making it easy to obtain fine adjustment.

The end fitting in the intermediate valve spindle was threaded 40 t.p.i., and the end carrying the valve driving nut 2-B.A. 31.4 t.p.i., thus one complete turn displaced the valve seven-thousandths of an inch up or down, depending on direction of rotation. A lock nut was provided to lock the valve spindle to the intermediate spindle.

A gunmetal dummy tail gland was made to replace the existing hexagon headed steel plug.

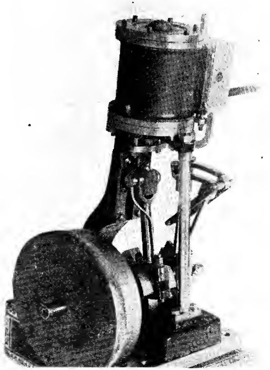
A new, and much thinner, steam-chest cover was made from steel plate and polished all over.

The steam-chest was filed up square all round and polished, at the same time the facing which had accommodated the steam inlet connection was removed and that side of the chest finished off flat.

The steam inlet and exhaust were on the same side of the engine, right next to each other. To give more space and to suit the new arrangements, I moved the inlet to the opposite side of the steam-chest, the screwdown stop valve being bolted direct to it by a flange and studs.

The original inlet hole and stud holes on the other side were covered by the base of the bracket which carries the reversing gear, this base also carries the displacement lubricator, which feeds through the original steam inlet hole.

New studs and nuts were made and fitted to secure the steam-chest and cover.



Flywheel only part machined

The cylinder was re-lagged, the old lagging plate was corroded, and anyhow, had nothing behind it. Before applying the new plate, the body was covered with thick flannel soaked in alum solution.

A cap was beaten up out of copper for the top cylinder cover, and the space between also filled in with flannel. This cap is secured to the cylinder cover by a central spacing stud and nut.

Incidentally, the knocking up of this cap was quite a job ; I only had some 16 s.w.g. copper sheet available and the depth of the flange is fully $\frac{5}{8}$ in., which, on 3 in. dia., is quite a lot, it means in effect, that starting with a disc $4\frac{3}{8}$ in. dia., the outer circumference has to be reduced, by hammer, from 13.74 in. to 9.42 in. ; this will give some idea of what an amenable metal copper is. Given patience, one can make it do almost anything ; the secret is frequently to anneal it, and never to try to force it when it shows signs of work hardening. The moment your mallet or hammer shows signs of bouncing or springing, cease hammering and anneal. The *feel* of the blow in flanging should always be *dead*, something like hitting soft lead.

The combined relief and drain cocks are shown in Fig. 1 ; as will be seen, the springs are adjustable and both valves are operated by one lever, and exhaust through a single pipe.

The drain valve fitted to the steam-chest is, of course, purely hand operated, and is of the plain screw-down type with wastepipe.

Fig. 2 shows the steam stop-valve, a built-up job with ample passages throughout, at least as large as the steampipe bore.

It is no use whatever providing large ports, passages, and slide valves with efficient valve gear, if at the same time you fail to provide adequate sized pipes for the steam supply and adequate passages through any valves controlling it.

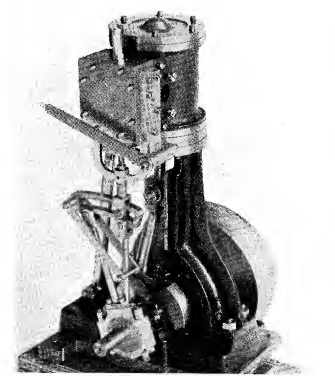
It is, of course, quite feasible to work an engine this way, it is also most inefficient. Such practice may well be likened to a man putting a large window frame in a room and then filling up half the spaces in it with plywood in place of glass !

The stop valve is a built-up job, silver-soldered together, the main body being made from a piece of $\frac{5}{8}$-in. sq. brass.

The cross handle (like the usual tender handbrake handle in locomotive work) is a type I favour, as it is quicker to operate than a wheel, it is a type used by both Saverys and Sissons in small marine plant.

Whilst on the cylinder unit, the valve spindle guide may be mentioned. The original one was an overhung bracket fastened to the bottom cover of the cylinder. Without actually checking it, I assumed that it was true, and as it was large enough in the body to take the increased diameter of the intermediate valve spindle, I decided to open it out. The method of doing this may be of interest.

Originally its bore was $\frac{3}{16}$ in. The faceplate was mounted on the lathe and a No. 48 8-mm. collet mounted in the nose adaptor with a short length of $\frac{3}{16}$-in. diameter silver steel held in it. The guide was pushed on to the silver-steel rod with the base to the faceplate. The base of the bracket was cemented to the faceplate with shellac and when set, the faceplate carefully removed, two holes drilled and tapped in it through the existing holes in the bracket base, and screws inserted ; on remounting the hole was checked and found to run dead true. It was then opened out with a small boring tool to 0.300 in. to suit the intermediate valve spindle. Sad to relate, this work proved to have been wasted ; the original had *not* been true, and the inaccuracies had been taken up by a slack valve spindle. However, out of evil may come good. A new guide was obviously called for. It is not a sound principle to have a guide for a spindle fixed in such a way that a variation in the thickness



Temporary erection

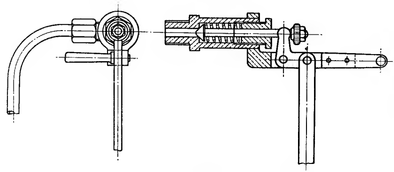


Fig. 1. *Auto-relief and drain-valve*

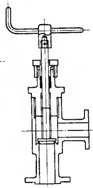


Fig. 2. *Stop-valve*

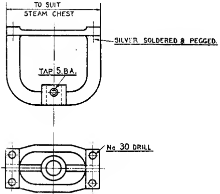


Fig. 3. *Valve spindle guide*

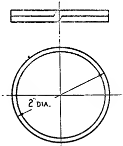


Fig. 4. *"Clupet" piston ring*

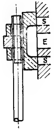


Fig. 5. *Details of slide-valve and ports*

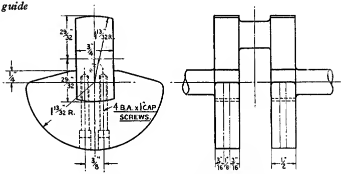


Fig. 6. *Crankshaft balance weight*

of jointing material can affect its alignment, which is the case in the original design, and an overhung bracket is not the best thing in the world to resist the side strains imposed by a link motion. I therefore schemed out and made a new double-ended guide, seated on the steam-chest itself, and, therefore, making up into a unit with it; this is detailed in Fig. 3, and shows up quite clearly in some of the pictures.

The next item to be tackled was the piston rod, as explained, the old one was badly corroded, and it was found that the neck-ring and gland were worn too. A new oversize rod was made, and, as the crosshead was in excellent shape, it was cut off from the old piston rod (they are solid in the Stuart No. 1) set up carefully in the four-jaw chuck and bored to take the new rod, which was pegged and brazed into it. The gland and neck-ring were opened out with an adjustable reamer to a nice sliding fit on the new rod. New fine thread studs and nuts were fitted for adjusting the gland. Here it is as well to point out that it is most important that the neck ring and gland should be a close fit on the rod, the packing is only an additional seal, and nc packing will give satisfactory service held between ill-fitting bushes.

(*To be continued*)

*MILLING IN THE LATHE By "NED"

Section 5.—Means of Driving Cutter Spindles

A general review of the principles, appliances and methods employed for adapting the lathe for various types of milling operations

ONE of the disadvantages of the rotary-spindle type of milling attachment, as compared to the use of appliances which utilise the lathe mandrel as the cutter spindle, is that special means of driving the spindle must be provided. As the latter does not work in a fixed position, being set at various angles and locations to suit the nature of the work, and also subject to feeding and traversing motion in taking a cut, it is no easy problem to devise a really satisfactory form of drive which will cope with all emergencies.

*Continued from page 622, "M.E.," Vol. 95 December 19, 1946.

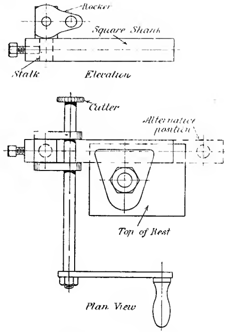


Fig. 41. *Hand-driven spindle with rocking adjustment for height*

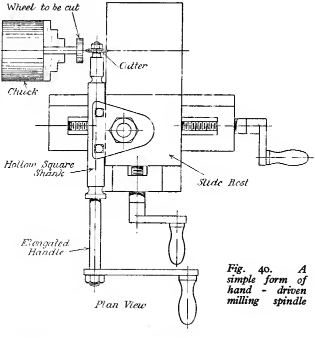


Fig. 40. *A simple form of hand - driven milling spindle*

The ideal cutter spindle drive would have to fulfil the following conditions: (1) apply a smooth torque to the spindle irrespective of its position or angle, without producing forces tending to vibrate the spindle or force it out of its set position; (2) furnish a full range of speeds to suit all materials and all classes of work being milled; (3) supply ample power (i.e. torque) to the spindle to enable cutters to be used at their full cutting capacity. It may be said at once that these conditions are rarely, if ever, satisfied in their entirety, but, nevertheless, there are several forms of drive which are very convenient in use, and give excellent results within their limitations. These may be classified as follows: (1) hand drive; (2) belt drive; (3) flexible shaft drive; (4) "motorised" drive, either direct, or through gears, belt, or flexible shaft transmission.

Hand Drive

This is the simplest and most primitive form of drive, but it

is, perhaps, the least hampered of all drives in respect of dealing with problems of spindle angle and location, and it enables ample torque to be applied to the spindle for most milling operations within the scope of this discussion, though at only a limited range of speed. It entails no more complication to the milling attachment than the provision of a crank handle to the end of the spindle, for providing cutter speeds up to about 120 r.p.m., which is sufficient for many milling operations with multi-toothed side cutters, on the harder metals, such as bronze, cast iron, or steel, but is not high enough for end milling or fly-cutter operations, especially on the softer metals. Higher speeds might possibly be obtained with direct hand drive for short periods, but are likely to be tiring, and the risk of shifting

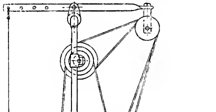


Fig. 42. Arrangement of overhead gear commonly used for treadle lathe

or vibrating the cutter by snatchy movement is accentuated. It is, of course, quite practicable to fit some kind of gearing to the spindle to enable the speed of the hand drive to be multiplied, but so far as experience goes, this is rarely done.

Certain positions of the spindle may be rather awkward for the application of hand drive, but generally speaking, it is as near universal in this respect as any form of drive can be.

While it is possible to adapt nearly any kind of milling spindle, with the exception of that used between centres in a cutter frame, to direct hand drive, it is generally advisable to construct a special spindle, having particularly long steady bearings, and an extension of the spindle, so as to carry the hand crank well clear of any projecting lathe fittings. This makes for comfortable handling and avoids the risk of damage to the knuckles in turning the crank.

A very simple form of hand milling spindle is illustrated in Fig. 40, applied to a spur gear cutting operation in the lathe. It will be seen that the bearing housing of the spindle is adapted to be clamped in the tool-post, being in the form of a square bar drilled through the centre and bushed at each end, similar to some of the devices previously described. The effective length of bearing must be sufficient to minimise the risk of springing or shifting the cutter by inadvertent side pressure applied when turning the crank, and the extension of the spindle beyond the bearing should not be carried to extremes, owing to the side leverage which may be exerted on a long projecting shaft.

In the example shown, no provision is made for height adjustment of the milling spindle, and packing would have to be used under the shank to bring the cutter to the required height. It is, of course, practicable to mount the appliance on a vertical slide to provide height adjustment, but in cases where the latter is not available, a simple means of height adjustment may be provided on the spindle itself.

The spindle illustrated in Fig. 41 has a rocking adjustment to the bearing, which in this case consists of a long tube, extending right from the cutter to the web of the crank handle, and preferably bushed at each end. Two lugs are attached to the tube by brazing or welding, and these straddle a trunnion block which may either be an integral part of the mounting shank or mounted on it, with a choice of two or more positions, as shown. The height adjustment may be locked by tightening the trunnion bolt, or a further refinement may be provided, in the way of an elevating screw adjustment, if desired.

The most serious practical limitation of hand milling drive is the difficulty of turning the spindle evenly and smoothly, without introducing side thrust, while at the same time manipulating one or more slide-rest adjustments at an equally smooth rate. It is consequently rather difficult to ensure accuracy and good finish by this method, but, nevertheless, some very useful work has been produced by its aid in the hands of painstaking operators.

Belt Drive

This method of drive, in some form or other, is by far the most popular for driving cutter spindles in the lathe, despite the problems which it involves in applying the drive at odd angles, and the limitations in torque or range of speed which it imposes.

It is necessary to provide, not only for reasonable alignment of the belt, but also for alteration

of the distance between driving pulleys, which would affect belt tension, in the absence of some means to take up slack in the drive. For the first, it may be said that the use of round belts, in grooved pulleys having a vee angle of about 60 degrees, and ample depth of groove, provide a fair latitude in respect of alignment, but it is necessary to use guide or "jockey" pulleys to enable drives to be taken at appreciably different angles. Belt tension is usually compensated by means of jockey pulleys on a slide, beam or lever loaded by means of a weight or spring.

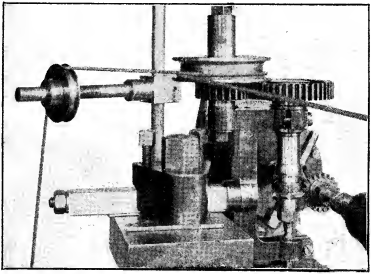
Overhead Gear

The most popular form of belt driving device for milling spindles is the well-known "overhead gear," which has been fitted to many types of instrument or ornamental lathes as a standard accessory. It consists essentially of a special countershaft adapted to the required purpose, situated at a sufficient height above the lathe bed to enable an efficient belt drive to be provided to the cutter spindle, and to avoid any interference with the normal operation of the lathe. Belt tensioning gear is usually provided. In treadle lathes, the countershaft is driven from the treadle shaft or foot motor by a long belt, the normal lathe belt being removed, as it is not required when milling operations are in progress (see Fig. 42). Power-driven lathes may have the overhead gear driven from the standard countershaft, or direct from the driving motor. In some cases, the normal power countershaft can be adapted to serve as the overhead gear shaft, but this may impose limitations which are undesirable.

The arrangement of overhead gear shown in Fig. 42 is a very common one, and it will be seen that the entire equipment is carried on a vertical frame attached to the back of the lathe bed. In some respects, this is open to criticism, as any vibration produced by the gearing is transmitted directly to the lathe, but it has been used with success for many years by innumerable operators. Mounting the frame or standards from the lower part of the lathe stand, or on an entirely separate foundation, may, however, be a very practical improvement.

To provide a range of speeds, it is usual to fit a cone pulley on the overhead shaft, having steps to correspond with those on the lathe mandrel (though not necessarily the same size), to take the drive from the treadle wheel; these, of course, may be either flat or grooved, according to the type of lathe drive employed. Another cone pulley may be employed to take the drive to the cutter spindle, in this case grooved for a round belt, of a suitable size to transmit the torque required, while at the same time sufficiently flexible to run freely in a path which may, on occasion, be very tortuous.

The method of maintaining constant belt tension will be clearly seen from this illustration. It consists of a beam mounted at the top of the frame, having at one end a bracket for the jockey pulley shaft, and at the other a weight hanger. Two grooved jockey pulleys are used, each running freely and independently on the shaft, as they will have to rotate in opposite directions when in use. It will be seen that the effect of the weight on the rear end of the beam will be to keep the jockey pulleys strained upwards, thereby maintaining practically constant tension of the belt, at all elevations or cross positions of the spindle. The counterweight may be varied in weight, or its leverage altered by hanging it at different distances from the pivot of the beam, to produce the belt tension desired; in some cases, the weight is substituted by a spring.



Application of "dwarf" overhead gear for driving vertical cutter spindle

To allow for variations of the lateral position of the cutter spindle along the lathe bed, the usual method is to make the spindle drive pulley adjustable along the overhead shaft, or in some cases a roller is fitted, on which the belt can align itself; but in this case the advantage of speed variation, provided by a stepped pulley, is absent. The jockey pulley beam is also made laterally adjustable, or the jockey pulleys may be mounted on a long shaft, on which they are free to float endwise and find their own alignment.

This form of overhead gear allows of using the cutter spindle horizontally, at any angle from that parallel to the lathe axis, as shown, to the cross position, provided that the position of the jockey pulleys enables something like correct alignment

of the belt to be obtained. It may be found desirable to provide means of adjusting the jockey pulley shaft along the beam, but swivelling adjustment of this shaft is rarely of any advantage. For other positions of the cutter spindle than horizontal, it is necessary to use another pair of jockey pulleys to change the angle of the belt from the near-vertical plane to the required horizontal or angular plane. These pulleys may be mounted on a bracket carried by the spindle housing, as described in dealing with rotary-spindle appliances.

Many variations of the overhead gear shown are possible, one of them being known as the "dwarf" overhead gear, in which the need for the standards and countershaft is eliminated, drive being taken direct from the treadle, through jockey pulleys mounted on brackets attached to the lathe bed. While these variations may offer advantages for certain applications, they are not so universally adaptable as the standard form of overhead gear, and are comparatively little used.

efficiency and increasing latitude in belt alignment and tension, this makes manipulation of the belt more difficult, and may be impracticable in workshops with low head room.

The form of bearings shown for the overhead countershaft is perhaps the simplest it is possible to fit, consisting of hardened and pointed bolts which engage in deep centres in the end of the shaft. This form of bearing was once very popular for treadle shafts and other purposes in light machine-tool practice, and can be made to run very smoothly, with little friction, if carefully fitted and well lubricated. It is not, however, well suited to continuous running, and some constructors may prefer to keep more in touch with modern practice by running the shaft in ball races or self-aligning plain bearings. The former call for large diameter housings, which may be in the form of castings, bored to fit the races, at right-angles to the socket which is attached to the standard. Unless races of the self-aligning type are fitted, the housings must be very carefully lined up, by using a straight mandrel

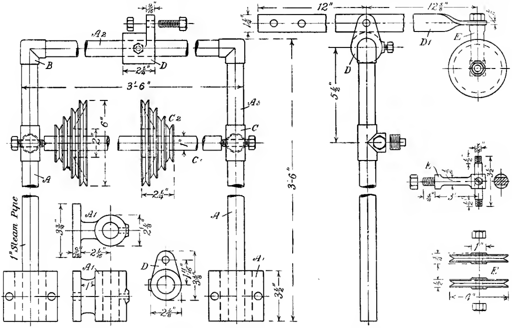


Fig. 43. *Components of overhead gear as illustrated in Fig.* 42

Construction of Overhead Gear

A simple form of the overhead gear shown in Fig. 42, which is suitable for use on most small lathes, is illustrated in Fig. 43. The framework is intended to be made from steel tubing, ordinary gas, water or steam pipe, with standard screwed fittings, being suitable, though in modern practice welded joints are just as easy to carry out, and will probably work out just as cheaply, or more so. The dimensions given will suit lathes up to about 4½ in. centres, and while it might be desirable to carry the overhead shaft at a greater height, to enable the length of cutter drive belt to be increased, thereby improving the driving

of the correct size fitted through the bores of both housings during assembly. Plain bearings may be found easier to fit, and run very smoothly if properly fitted, besides being quieter than ball bearings. Either gunmetal or cast-iron bushes will give excellent service for this class of duty, if regular but sparing lubrication is supplied.

The left-hand cone pulley should take the size and type of belt used for driving the lathe mandrel, and line up with the treadle pulley, the size of the steps being adjusted to provide constant belt tension at the different speeds. Means should be provided for shifting the other cone

(*Continued on page* 28)

TUBE BENDING FOR THE AMATEUR

By W. RANN

WHEN one considers that there is hardly a machine or vehicle without some form of bent tube or pipe work, it is surprising how little is known, or has been written, on this subject. Tube bending is usually undertaken in most works, large or small, by coppersmiths, who, in most cases, have a fair knowledge of the job. In production of large quantities of similar bends, special machines are designed and used, which are operated mostly by unskilled labour.

The writer's object in this article is to assist the model engineer in carrying out the bending of tube or pipe with the minimum number of tools, etc.

The bending of thick tube presents very little difficulty, for it will not flatten unduly, or kink in the bend, provided the bend radius is not too sharp ; for instance, not less than three times the tube diameter. It is the bending of thin tube where the amateur finds the difficulty.

Dealing with copper and brass tube first, a rough layout should be prepared showing the position, radius and angles of the required bends.

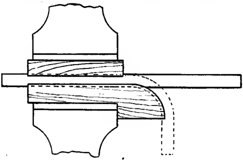


Fig. 1

This can be scratched on a sheet of metal, or pencilled on a board, or even chalked on the bench, according to the accuracy of the bends required. When cutting the tube to length, allow sufficient to spare at each end.

Annealing is the next job, and the tube can be annealed all over, or approximately at the position of the bend. Copper is best annealed by heating to a dull red, then plunging it into cold water, and brass the same, or leaving it to cool off in the air, whichever suits the metal best.

The next operation is loading the tube, and several kinds of filling can be used. Sand or resin or one of the low-temperature metals which are on the market for this purpose. Resin is the most common filler, and should be mixed with about one-third pitch to prevent cracking while bending. A wooden plug should be driven into one end of the tube and the resin heated in a ladle. The tube should be pre-heated slightly and then the resin poured into the tube slowly, the latter being held slightly at an angle to prevent formation of air bubbles. At least two or three hours should elapse before the tube is bent, to insure gradual cooling.

If any metal fillers are used, such as "Bend Alloy," "Cerro Bend," etc., the tube should be plugged at one end as before and filled with a ladle, the heating and cooling of the metal filler being done according to the instructions supplied by the makers.

The sand used for filling must be quite dry and fairly fine, silver sand being best for the purpose. Plug the tube as usual and fill with sand. Then the tube should be gently tapped with a thin piece of wood or a hammer shaft, and the sand will be seen to sink. Continue filling and tapping until no more sand can be got into it, when another plug can be inserted to retain the sand.

To obtain a nice clean bend it is well worth while to make up a few rough tools. The wooden vice former (Fig. 1) should be approximately the same thickness as the diameter of the tube, and cut as shown. The radius of the bend should be slightly less than required on the tube to allow for spring. The filled tube can be held as in

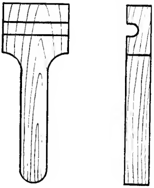


Fig. 2

Fig. 1, and carefully pulled round by the fingers. Should the tube be too stiff, a simple bender (Fig. 2) can be made up out of any odd piece of wood and used on the overhanging tube to bring it round tight against the former. If more than one bend is required, it is worth noting the amount of spring, so as to make the necessary allowance when setting up in the vice.

Sometimes a tube is required to be bent into a continuous curve throughout its length. It might be of constant radius or a profile to fit round inside somewhere ; Fig. 3 shows a useful wooden former for this kind of job. The edge should be grooved slightly with a round file to prevent forming a flat on the tube. The radius of the former should be a bit less than required, as it is very easy to set back the tube should it be bent too far. This type of former can be used for several different diameters by merely changing the clip.

The above notes should cover the bending of

most jobs in brass or copper, but it must be remembered that tubes filled with sand require more careful handling than those filled with resin or metal.

A word about aluminium tubes. This material is more likely to break, and it is advisable to anneal before bending. Rub the aluminium with a piece of ordinary soap, then pass through a gentle flame and immediately the soap marks turn brown; quench in cold water. When quenching tubes, keep out of the "line of fire" of the tube end, as the water rushes up and you may get scalded.

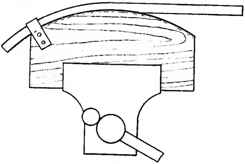


Fig. 3

Tubes filled with resin are best unloaded by gently playing a flame up and down the tube until the resin melts sufficiently to run out. Metal-filled tubes should be immersed in a tank of boiling water until the metal melts, when it can then be emptied into a suitable container. Before passing the tubes into service, they should be cleaned out with a piece of rag on a wire so as to make sure there is no particle of sand or metal left inside, which might cause damage if it were to break loose.

Bending steel tube is quite a different proposition, as rough wooden tools are not strong enough; for steel tubes have to be bent red-hot, which calls for quite a different technique.

Sand is the usual filling medium, and the importance of it being absolutely dry is stressed once again. With hot bending, any moisture in

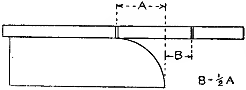


Fig. 4

the sand would generate steam, causing either a plug to blow out or even the tube to burst, resulting in a shower of red-hot sand, which can be dangerous.

Plug and load in the usual way, making sure the plugs are a good tight fit. Mark out a diagram of the bends required, then chalk the bend lines on the tube, as shown in (Fig. 4). Lay the tube on the forge and play the blow-pipe on one side only, taking your time in heating up, as the sand must be hot as well as the tube. When a bright red on one side, put it quickly in the vice, with the hot side away from you and slowly bend the tube by pulling towards you. Have a piece of wet rag handy and apply it to the inside of the tube as you pull it round, thus preventing the heat from spreading to that side, which might cause wrinkling. Watch bending carefully and stop if it shows signs of going in one place. In any case, it will probably only bend to about 45°. To finish the bend bring the blow-pipe up to the vice; and play the flame on to the outside of the

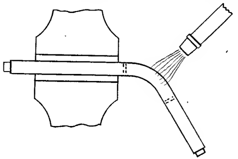


Fig. 5

bend (see Fig. 5), at the same time pulling the tube round steadily. Bend to about 5° past the required angle, then bring the blow-pipe round and heat up the *inside* of the bend until about cherry-red, then push the bend back to the right angle. This will remove the slight flattening that takes place and leave a perfect bend. Where several bends are required in one tube, it is advisable to tap down the sand a bit before starting the next bend, as a certain loss of pressure takes place in the bending.

This article should enable the model engineer to produce nice even bends in oil or steam pipes or any structure made of bent tube, and good bends can make all the difference in the appearance of a model.

Milling in the Lathe

(*Continued from page* 26)

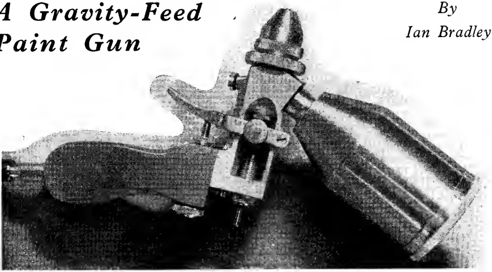
pulley along the shaft, a readily accessible set-screw being the simplest method of fixing; the bracket for the jockey pulley beam should be similarly adjustable on the top tube of the frame. The brackets to carry the feet of the vertical tubes may be modified to suit the method of mounting, either by attachment to the lathe bed, or any other method which may be adopted. Cross-bracing of the frame may be found desirable to promote rigidity, and is easily carried out by bolting diagonal strips of about ½ in. × ¼ in. flat steel across the space below the overhead shaft.

Although the jockey pulleys are shown as having vee grooves, it will be found that semi-circular grooves produce less friction, and work best under conditions of misalignment.

(*To be continued*)

A Gravity-Feed Paint Gun

By
Ian Bradley



The gun, showing paint needle clamp-screw and air-valve

HAVING in the past successfully made up two of THE MODEL ENGINEER paint guns, I thought it might be interesting to see whether the production of a commercial type of gun was a possibility for the amateur. The results, based on a commercial pattern, are illustrated and described herewith.

Before going into the operation of the gun and certain details of its construction, which it is hoped will interest readers and perhaps stimulate them into suggesting improvements, I ought, perhaps, to remark that in the case of a professionally made article the main framework would obviously be a one-piece casting. But I came to the conclusion that those people who might like to make such a thing for themeselves would not be averse to carving the main portions from the solid, an undertaking that is in reality nothing like so exacting as it might appear at first sight, but certainly repays one for the trouble in excellence of appearance.

In construction, great care should be taken in cutting all screw threads. The successful working of the gun depends entirely upon the accuracy of machining. Therefore, all threads should be lathe cut where possible and those which cannot be so cut should be either died down or tapped in the lathe.

How It Works

In dealing with the working of the gun, the general arrangement drawing (Fig. 1) will, I think, make the matter quite clear. From this it will be seen that air enters by way of the hollow stock (1) and under control of the air-valve (2) in the top of the stock, passes along passages drilled in the main portion of the gun body (3), emerging from it into the combining cone (4). The air then passes over the exterior cone (5) of the paint-valve (7) and combines with the paint at the discharge orifice (6) of the combining cone. The paint itself is under control of the paint-valve (7) to which it flows by gravity from the container (8). Both air and paint-valves are operated by the trigger (9) and are so arranged that the paint-valve opens slightly in advance of the air-valve. The paint-needle (10) is so arranged that it can be instantly removed for cleaning purposes. I had thought that this arrangement might be an advantage in that, by varying the relative "timing" of the air- and paint-valves (the adjustment is carried out by the clamping-screw (11) which secures the paint-needle to the trunnion (12)), the paint/air ratio might be varied at will. However, practice has shown, with thin fluids at all events, that there is not much advantage to be gained from this, but that if both valves are set to open simultaneously the best results are obtained. On the other hand, when more viscous fluids are to be handled, it may well be that the ability to make some adjustment is an advantage, though, as yet, there has been no opportunity to check this point.

Air-valve

As will be seen from the enlarged detail, this valve consists of a short plunger (13) to which a rubber or leather disc (14) is secured by a screwed cap (15). The cap forms a seating for a compression spring (16), whose free end is held in the valve cover (17), which is provided with a fibre washer (18) to prevent air leaks. The valve plunger is carried in a bearing formed in the stock and is glanded against air leaks by the packing (19) which is compressed by the knurled nut (20). After assembly this valve should require little or no attention, since, by the passage of air, it is practically self-cleaning.

Stock and Body Joint Thimble

As this detail shows clearly in Fig. 2, it is perhaps an opportune moment to say a few words

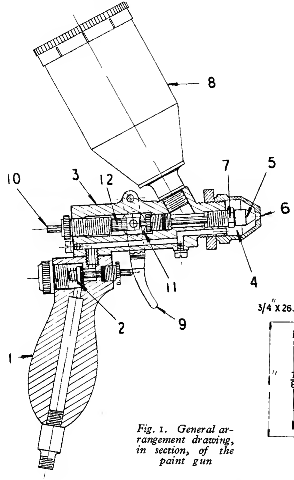
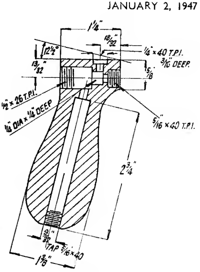


Fig. 1. General arrangement drawing, in section, of the paint gun



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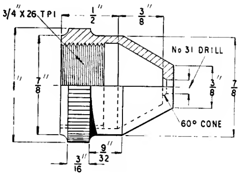

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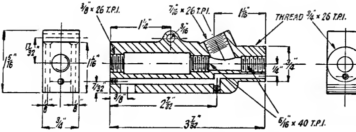

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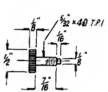

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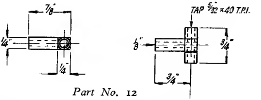

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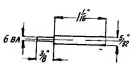

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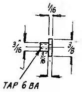


Part No. 15

about it. In making the gun from the solid, it was thought convenient, both on the score of material available and for ease in manufacture, to divide the stock and the body. This entailed making a joint that was at once sound mechanically, of ample strength and free from air leaks. At first it had been the intention to use a hollow dowel to effect a register and permit the transfer of air, released by the air-valve, from the stock to the body. The mechanical joint was to have been

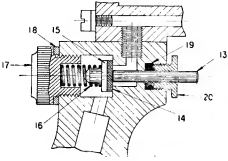


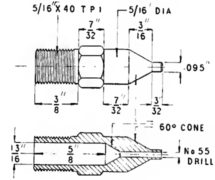
Fig. 2

made by long countersunk screws passing through the body into the stock; indeed, this arrangement shows in the original detail drawings reproduced herewith. Further thoughts on the matter suggested that a hollow dowel screwed $\frac{1}{4}$ in. × 40 threads per inch would be the better solution, as it would eliminate the distinctly unsightly set-screws and form a better joint.

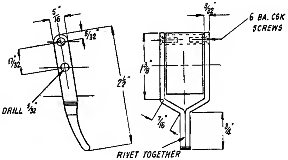
This has proved to be the case in practice, though the operation of boring and tapping the two mating parts needs some care to ensure that their sides register flush and do not butt together with a stepped joint. It may be possible to set up the work accurately enough from direct marking-off, but to make quite sure of the setting it pays to use a tool-maker's button and "clock" the work when set up on an angle-plate bolted to the lathe face-plate. I think this method is preferable to drilling and tapping in the drilling machine, as it is then possible to take light facing cuts from the second of the components to be machined, thus making sure that the stock and body are dead in line when screwed tightly together.

Paint-valve

Here again I am giving an enlarged section in Fig. 3. The general arrangement drawing Fig. 1 shows the disposition of the paint needle (10), the trunnion (12) which is operated by the trigger (9), the clamping screw (11), and the exterior of the paint-valve (7), but does not show the whole mechanism in section. From Fig. 3 the construction of the paint-valve as a whole will be clear. The needle (10) is carried in the trunnion (12), which is loaded by the spring (22), thus keeping the needle up against the valve seat. To prevent leakage of paint there is a gland made up of three components, a screwed abutment (23) to prevent the gland packing being forced into the cavity below the container, compressed cork packing (24) and a gland nut (25). The paint needle, as I have said previously, may be instantly removed for cleaning by undoing the clamping screw and withdrawing the needle bodily through the spring box (26). The clamping screw serves also as one of the trunnion screws, the other being permanently fixed in the trunnion.



Part No. 7



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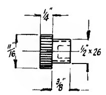

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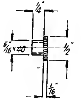

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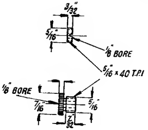
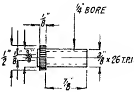


Parts Nos. 23 *and* 25



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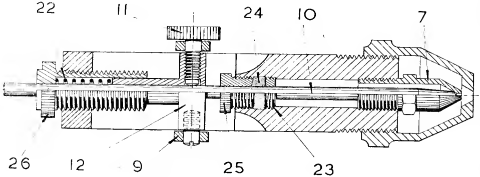


Fig. 3. Section of paint-valve

The Valve Body

Part No. 7, the paint-valve body, has been the subject of a certain amount of local research and the form now shown in the drawings appears to give the best results. It will be seen that the body is coned 60 degrees externally and internally. The internal cone is formed by drilling with a Slocomb centre drill, as this is the proper way to ensure the axial truth of the cone. The exterior cone must also run dead true or the gun will not shoot straight. The valve body should be mounted in a screwed adaptor held in the chuck; this will effectively prevent any errors in machining the cone.

Paint Container

As this component will, no doubt, be a matter for a forage in the scrap box, I am not giving any detailed drawings for it. The container shown in the illustrations was made up from four pieces of scrap and constructors will no doubt be able to make up something like it from their own resources.

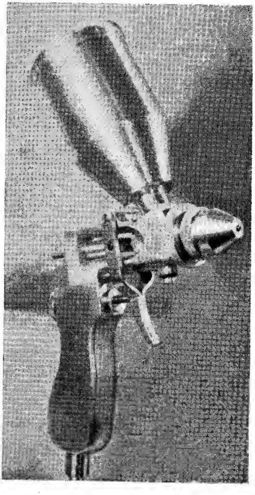
Trigger Fulcrum

Here again I have not detailed out the component fully, but reference to the drawing for the trigger (9) will show that there are countersunk screws at the pivot end of this item. These screw into a short length of $\frac{3}{16}$-in. mild-steel rod which is tapped $6\frac{1}{2}$ B.A. at each end. The rod should be about 0.010 in. longer than the width of the gun body and, in order to centralise the trigger, two $\frac{1}{4}$-in. diameter washers should be interposed between the arms of the trigger and the ends of the rod.

As to the machining of other details not specifically mentioned, space does not permit the giving of fully-detailed instructions. If, however, any problem does arise, I shall be only too happy to help through these pages if the Editor will permit.

Further Experiments

Since writing the above I have been able to carry out further experiments with the combining cone (4) and the paint-valve body (7). As a result, the details of these two components differ materially from those shown in the general arrangement drawing (Fig. 1), and the section of the paint-valve (Fig. 3). The details now given for parts (4) and (7) are those which have given the best results.



Another view of the gravity-feed paint gun

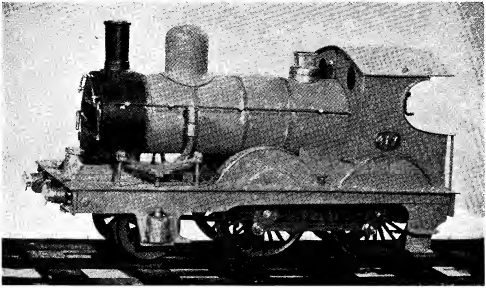


Photo by] [*E. A. Jackson*

Mr. C. V. Bavin's $2\frac{1}{2}$-in. gauge model of the G.E.R. 2-4-0 mixed traffic locomotive, "Petrolea's Little Sister"

A WAR-TIME EFFORT

By C. V. BAVIN

HAVING read one of friend Hambleton's articles on old-type locomotives which dealt with the Great Eastern Railway's 2-4-0 mixed traffic engines, aptly named by the author "Petrolea's Little Sister," it occurred to me that a pretty little engine could be made to that design in $2\frac{1}{2}$-in. gauge.

A rough working drawing was made, and with the decision to make it a quick and simple job, a "Smithies" boiler and one cylinder with slip eccentric-gear was incorporated.

Referring to back numbers of THE MODEL ENGINEER, "L.B.C.S.'s" single-cylinder 4F. 0-6-0 was turned up, the motion of which was adapted to suit.

The war still being on with the attendant difficulties to get materials, the various stock in hand was made use of, which comprised two pairs of coupled wheels $2\frac{7}{8}$ in. dia., a pair of bogie wheel castings $1\frac{3}{4}$ in. dia., two pieces of 3/32-in. frame steel, some stout tinned iron,a large brass bolt-head for the cylinder, and a piece of thin sheet copper which would make the inner boiler shell.

The frame steel was 1-in. shorter than required, so the drawing was re-arranged, cutting down the distance between the coupled axles.

Two pieces of what the local blacksmith called hooping iron over $\frac{1}{16}$ in. thick made the combined frames and footplate edging carrying the leading wheels. Buffer beams were made of the same material with the necessary angles riveted to them for the erection of the frames.

Spring axleboxes are provided for all wheels, the leading axlebox springs being taken from electric light fittings recessed into the top of the boxes and bearing on the frames.

The cylinder was made up from the brass bolt-head, the surplus being sawn and machined off in the lathe, using four-jaw chuck, the "words and music" relating to the 4F.'s cylinder being adhered to.

A crankshaft was brazed up with eccentric and strap, as in the 4F.

Footplates were made up from the turned iron as was the cab and splashers and soldered together.

The brass beading round the edges of the splashers was provided by making the tops of the splashers of brass sheet, about 3/32 in. thick, and leaving the outer edges bright.

A smokebox was built of 16-gauge sheet brass and brazed up with "Easyflo," the door being a push-in fit, with dummy hinges of stainless steel.

A chimney was turned up from a piece of thick $\frac{3}{4}$-in. dia. brass tube, flanges to fit on the smoke box dome of sheet brass hammered out to shape and silver-soldered at the joints.

The displacement lubricator fitted between the frames just in front of the smokebox rather spoils the appearance.

Turning to the boiler, the outer casing is made of galvanised sheet, and the inner barrel of the

piece of thin copper sheet rolled up and brazed with three $\frac{3}{16}$-in. water tubes brazed in.

A screw-down type of regulator, a spring-loaded ball safety-valve, blower-valve and test cock comprise the boiler mountings along with a check-valve.

Provision is made to replenish the boiler by a hand pump in the tender now under construction *via* the check-valve on the right-hand side of the boiler. A dummy check-valve is fitted on the opposite side of the boiler barrel for appearance sake.

At present a four-wick methylated spirit burner is fitted for firing, but an axle dodger paraffin burner is contemplated.

Steam tests have been postponed until the tender is finished. Air tests have proved satisfactory.

Suitable blue enamel is being sought for, which appears to be very difficult to get hold of.

Concluding, I would like to offer my appreciation for the very interesting articles by Mr. Hambleton, and I hope they will be continued for some considerable time.

Letters

A Self-acting Feed

DEAR SIR,—I was very interested in the machine vice illustrated on page 564 of the December 5th issue. Like Mr. Granger, I have one of these small Adept shapers and shall certainly use his idea for certain jobs.

I have found the usefulness of my machine greatly increased since fitting a self-acting feed mechanism which I made quite simply. I have not the facilities to make a drawing of it, but if the Editor cares to put any interested Bristol reader in touch with me I should be pleased to show him, and perhaps he might make either a photograph or drawing for the benefit of other owners of these very useful little machines.

Yours faithfully,

Bristol. L. F. BISHOP.

Small Turbines

DEAR SIR,—I have no desire to prolong the discussion on the relative thermal efficiencies of small turbines and small reciprocating sets, but I would crave space to reply to Mr. Walter Elkin's letter. I do not agree that steam consumption "would be one of the last considerations in the mind of the designers"; I know something of German designers and the German mentality, and I am very certain the thermal efficiency of their turbine was given most serious consideration. This is borne out, as, in effect Mr. Elkin admits, by the fact that steam consumption was as low as 16 lb. per b.h.p. hr.

Just what Mr. Elkin's arguments amount to in the first part of his letter I really can't see. I never suggested that a reciprocating engine was suitable for use in a rocket; it is very obviously not. Later Mr. Elkin says he has "yet to hear of a reciprocating engine that uses less than about 35 lb. of steam under similar conditions." Similar conditions to what? If he refers to use in a rocket, he will probably never hear of one. If, on the other hand, he is referring to a steam engine working non-condensing, then I can quote him engines built forty years ago working non-condensing using as little as 25 lb. of steam per b.h.p. hr., and modern engines of the simple twin-cylinder type as little as 14 lb. of steam per b.h.p. hr.

That is the whole gist of my arguments. I say that up to probably at least 100 h.p., no turbine yet designed and built can compete with the best reciprocating types *on a purely steam consumption basis.* I am in no way decrying the turbine by calling attention to this state of affairs; quite often its special qualities entirely outweigh this handicap, as in the very obvious case of the rockets. Mr. Elkin's figures for his small turbines are extremely creditable. I have not made or tested anything in the reciprocating line at all comparable in size.

I believe, if I got down to it, I could produce a small reciprocating engine to give better steam consumption than Mr. Elkin's turbines; but it seems to me that, whether I could or not, is entirely beside the point, which is that it can be done without much difficulty, and I am very certain, leaving myself out of it, that there are many capable people who would find no difficulty in doing it.

The type of argument which depends on "can you do it yourself?" is a very weak one; carried to its logical conclusion, it would seem that no man could become a C.M.E. of one of our railways unless he could build a complete locomotive himself. Those familiar with the hundred and one trades and techniques involved in building a locomotive will realise that such a qualification could never be fulfilled by an ordinary human.

At the risk of repeating myself, I have every respect for the small steam turbine, a great interest in it, and a keen desire to see it developed to the highest point of efficiency. All this does not alter the fact that, in sizes likely to interest model engineers, its thermal efficiency is, and is likely to remain, much lower than that of a well-designed and constructed reciprocating engine of similar power. To argue otherwise is to argue against existing facts, and does nothing to further the cause of the turbine, which does possess many advantageous characteristics peculiar to itself.

Just one other point; Mr. Elkin quotes, quite correctly, a consumption of 6 lb. steam per b.h.p. hr. as usual for turbines. He then says "no reciprocator can approach this." Well, he is quoting power station conditions with plant running to thousands of horsepower; Doble has, with a triple expansion engine with reheater stages, produced 1 b.h.p. per hr. for 7 lb. of steam with an engine of around 100 b.h.p.; not perhaps so distant an approach after all, more especially considering the enormous disparity in sizes. When a 100 h.p. turbine is produced to equal these figures, I will be the first to rejoice.

Yours faithfully,

Harrow. K. N. HARRIS.